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Commercial & Government
Pesticide Applicator

BASIC

Manual



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INTRODUCTION

All pesticide applicators are required to know basic safety and handling rules for pesticide use. The purpose of this “Basic Pesticide Training Manual” is to help individuals wishing to become applicators learn those facts.

Applying pesticides requires many special skills and responsibilities. It is an important occupation on its own and an indispensable part of many other occupations. Those who apply pesticides or supervise pesticide applicators must be sure pesticides are handled and applied properly and safely. It is necessary to identify pests and then select the best method or methods for their control. For personal safety, as well as that of co-workers and family, it is essential to understand the hazards of pesticides and how to avoid injury. Protecting the environment is also a major concern. Additionally, it is important to be familiar with all state and federal laws regulating the use, storage, transportation, application, and disposal of pesticides.

This is the basic or core manual for all pesticide applicators and dealers. This manual is to be used by all applicators who wish to be licensed or certified in any Montana pesticide applicator category. Applicators will also need to review other manuals appropriate to their specific applicator category(ies), the Montana Pesticide Act, and the Act’s associated Administrative Rules of Montana (ARM 4.10.101-1808).

To simplify information, trade named products and equipment have been mentioned. No endorsement is intended, nor is criticism implied of similar products or equipment which are not mentioned.

Developed by the Montana Department of Agriculture:
Technical Services Bureau, Agricultural Sciences Division

Heidi Hart
Laura Hinck
Kim Johnson
Barbra Mullin
David Rise
Donna Rise
Kari Smith
Dan Sullivan

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CHAPTER I

PESTICIDE LAWS AND REGULATIONS

► Federal Laws and Regulations

Insecticides and fungicides were the first pesticides to be regulated with the enactment of the Insecticide Act of 1910. The 1906 Pure Food Law was expanded in 1938 to include regulations governing the use of pesticides on food. In 1947, the 1910 Insecticide Act was replaced by the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA).

FIFRA - Enactment of FIFRA expanded the scope of pesticide regulation. New regulations required that all pesticides moved in interstate commerce be registered by the United States Department of Agriculture (USDA), that pesticide usage be safe, and that all pesticides be properly labeled by manufacturers. The intent of labeling is to ensure the safety of the public by requiring proper product use instructions. Packaging and safety regulations were added to FIFRA through several pieces of legislation from 1950 to 1970.

In 1970, federal responsibility for regulating pesticides under FIFRA was transferred from USDA to the U.S. Environmental Protection Agency (EPA). The 1972 amendments to FIFRA gave EPA principal authority to control pesticides, to register and inspect producing establishments, and to certify applicators using pesticide products designated as restricted use. The amendment also extended federal registration of pesticides to include those distributed or used within states. FIFRA was again amended in 1978. The 1978 amendments required EPA to establish criteria for data submission requirements in support of product registration. EPA stipulated that data submitted to support an original product registration could not be used to support registration of other products for a period of 10 years. More importantly, the 1978 amendments gave states primacy with regard to enforcement of pesticide laws, provided that states have established an EPA approved plan for such activities.

Amendments to FIFRA in 1988 are referred to as "FIFRA Lite". These amendments established a five phase re-registration process for all pesticides registered prior to November 1, 1984, based on pesticide active ingredients. Assessment of fees by registrants was set to generate \$14 million per fiscal year to support personnel and resources necessary for re-registration activities in a timely manner. Regulations were also published for pesticide container design, promoting safe storage and disposal of pesticide containers, and prescribing procedures and standards for removal of pesticide residues from such containers. The following summarizes some of the more important provisions of FIFRA.

Registration - The distribution, sale, offering or holding for sale, shipment, delivery or receipt within any state of any pesticide which is not registered with the EPA is prohibited. To register a pesticide, the applicant files a statement that includes a copy of the labeling, the claims to be made for the pesticide, directions for its use, and the complete formula of the pesticide.

EPA has the authority to cancel a pesticide's registration if it is later determined that the directed use of the pesticide poses a serious hazard to humans or the environment. A registrant can appeal an EPA cancellation notice through a process of public hearings and review by a scientific advisory group. Suspension of a pesticide registration, unlike cancellation, stops interstate shipments immediately, but can be initiated only when the product presents an imminent danger. The EPA Administrator may issue a "stop sale, use or removal" order when it appears that a pesticide violates the law or its registration has been suspended or finally canceled.

FIFRA, as amended, requires the registration of all pesticide producing establishments. Information, which includes the types and amount of pesticides produced, distributed and sold, must be submitted upon registration of the firm and annually thereafter.

In 1996, the Food Quality Protection Act amended FIFRA. Amendments included the establishment of a system for reviewing pesticide registrations and tolerances on a 15-year cycle, authorization for EPA to suspend pesticide registrations immediately under emergency conditions, and requirements that EPA develop criteria for reduced-risk pesticides and expedite their registration.

Classification of Pesticides - The 1972 amendments required that all pesticides be classified as general or restricted use.

A General Use pesticide is defined in FIFRA as one which *will not generally cause unreasonable adverse effects on the environment* when used in accordance with its labeling. Such pesticides normally are available to the public without a license.

Restricted Use pesticides are defined as those which *may generally cause unreasonable adverse effects on the environment, including injury to the applicator*. Those pesticides placed in the restricted category may be used only by or under the supervision of certified applicators or under such other conditions as EPA may require to protect humans and the environment.

If the EPA Administrator determines that some pesticide uses should be general use and that other uses should be restricted use, the administrator must register it both general and restricted use. It is essential, however, that the directions relating to its general uses be clearly separated and distinguished from those directions relating to its restricted use.

Classification of Pesticide Applicators - The 1972 amendments define two classes of applicators, commercial and farm (private). EPA was directed to establish separate standards for each type of applicator.

A farm (private) applicator is defined in FIFRA as a certified applicator who uses or supervises the use of any *restricted* use pesticide for the purpose of producing any agricultural commodity on property owned or rented by the applicator or his/her employer. Montana regulations allow *only* the application of general use pesticides on property of an immediate or adjacent landowner, if applied without compensation other than trading of personal services between producers.

A **commercial applicator** is defined in FIFRA as a certified applicator (whether or not he/she is a farm [private] applicator) who uses or supervises the use of any *restricted* use pesticide for any purpose or on property other than as provided by the definition of farm (private) applicator. Certified applicators may be classified in one or more applicator categories.

Certification of Applicators - States are expected to develop and administer applicator certification procedures based on standards of competence which meet or exceed those prescribed by EPA. The State of Montana certification program was originally approved by EPA in 1976. An amended certification plan was submitted to EPA in 1986 and was approved in June 1987.

Farm (private) applicators wishing to purchase and apply restricted use pesticides must first become certified. Certification may be achieved by (1) attending a pesticide training course and completing an ungraded exam at the end of that training course or (2) by taking the Farm Applicator's Examination without the benefit of the pesticide training course. A score of at least 70% is required for certification if this option is chosen.

Commercial applicators must demonstrate practical knowledge of the principles and practices of pest control and safe use of pesticides by taking a graded examination. Exams are based on manuals available from the Montana Department of Agriculture (MDA). Written testing is based on examples of problems and situations appropriate to the particular category or subcategory of the applicator's certification. A score of at least 70% is required for licensing to apply general use pesticides. A score of at least 80% is required for a *certified* license to apply restricted use pesticides.

Standards of Competency for Commercial Applicators - All commercial pesticide applicators must receive training in each component of the training standards. However, the content and emphasis may vary depending on the types of activities carried out under a particular license. For example, practical knowledge of drift problems should be required of agricultural applicators, but not of seed treatment applicators. The latter, however, should be particularly knowledgeable of the hazards of and the safety precautions necessary for working with treated seed.

Montana Commercial Pesticide Applicator Training Standards

- ❖ **Labels and Labeling**
- ❖ **Safety**
- ❖ **Environment**
- ❖ **Pest Identification and Biology**
- ❖ **Pesticide/Chemical Control**
- ❖ **Equipment**
- ❖ **Calibration**
- ❖ **Laws and Regulations**

FIFRA has outlined general types of applicator categories, but gave states the right to further specify applicator categories and to define the specific applications of each applicator category. Further explanation and description of Montana applicator categories may be found in the licensing section under state regulations.

Penalties - FIFRA provides for criminal and civil penalties to be assessed for violations of provisions of the Act. Civil penalties are assessed administratively by EPA on those persons and/or companies who violate any portion of the Act. Any manufacturer, commercial applicator, dealer, or distributor may be fined up to \$5,000 for each offense. Farm (private) applicators or others not mentioned above are given a written warning and/or a fine of up to \$500 for the first offense. However, on subsequent offenses, a farm (private) applicator may be fined up to \$1,000. Fines for civil offenses may be determined and imposed by the Regional EPA Administrator. Persons assessed a civil penalty must be given notice and be provided the opportunity for a hearing.

Criminal penalties are more serious violations of the law and are usually decided in courts. Persons or companies and farm (private) applicators who knowingly violate the provisions of the Act may be found guilty of misdemeanors. In this case, the key phrase is "knowingly violates." Conviction of companies or commercial persons under this category will be subject to a fine of up to \$25,000 or one year in prison, or both. Farm (private) applicators who are found guilty of misdemeanors under this portion of the law may be fined up to \$1,000 or imprisoned for 30 days, or both.

If the EPA Administrator is unable to collect the fine levied as a civil penalty, he may turn the case over to the U.S. Attorney General who can then take the case to the U.S. District Court.

► State Pesticide Laws and Regulations

At the federal level, FIFRA sets the laws and regulations governing pesticides and dictates the enforcement necessary under those laws and regulations. States are given primary enforcement authority when they have adopted adequate state

laws and regulations and have adequate procedures for enforcing state law, keeping records, and making reports of all enforcement activities. State laws and regulations may not be less restrictive, but may be more restrictive, than the federal laws and regulations established under FIFRA. Montana

FIFRA VIOLATIONS

- Selling a restricted use pesticide to a person not certified to purchase such products
- Using a pesticide in a manner inconsistent with its labeling
- Selling a pesticide that is not registered or for which the registration was canceled or suspended
- Selling a pesticide that makes claims that are different or is different in composition from that which was submitted at the time of registration
- Selling pesticides which are not colored or discolored as required by EPA
- Selling adulterated or misbranded pesticides or misbranded devices
- Altering, defacing or detaching a pesticide label
- Failure to keep required records or to allow inspection, copying or sampling
- Providing a false guaranty
- Advertising a restricted use pesticide without giving the information that it is a restricted use product
- Using an experimental pesticide contrary to the provisions of the experimental use permit
- Violating any stop sale, cancellation or suspension order
- Producing pesticides without registering as a pesticide producing establishment
- Failure to keep records of pesticide production
- Falsification of any application for registration, report, or record or any data submitted to EPA
- Using pesticides in tests on humans unless they are fully informed

has established a cooperative agreement with EPA and has assumed the primary responsibilities of administering FIFRA programs.

In 1947, Montana adopted its first pesticide law, entitled the "1947 Insecticide, Fungicide and Rodenticide Act." This Act was administered by the Department of Health and required registration of all economic poisons (pesticides) in Montana. This law was repealed July 1, 1971. Since then, several other laws affecting the use of pesticides have been enacted.

Montana Pesticides Act (MPA) - The Montana Pesticides Act (MPA), Title 80, Chapter 8, Sections 80-8-101 through 80-8-306, MCA, enacted by the 43rd Legislature in 1971, is administered by the MDA.

The MPA is comprehensive in its regulation of the sale and use of pesticides. The Act may be subdivided into three major areas of responsibility: registration of pesticides; licensing of pesticide applicators, operators, and dealers; and enforcement and administrative procedures.

Registration of Pesticides - All pesticides must be registered by the EPA. All EPA registered pesticides must also be registered with the MDA before they may be legally offered for sale or used in Montana. Montana also registers pesticides formulated within the state. The annual registration fee is \$150.00 per pesticide product registered. All registrations expire each year on December 31 following the date of issuance and must be renewed annually.

Montana must register all federally registered pesticides upon receipt of such registration from the registrant. The MDA has the authority to impose additional restrictions on the use and application of pesticides within the state. The state may restrict application of certain pesticides to type of applicator, time and place. The MDA may suspend or cancel the registration of a pesticide whenever it does not appear that the product or its labeling comply with the MPA or scientific evidence proves that the product endangers humans or the environment.

The MDA is given the authority to sample, inspect, and make analysis of pesticides distributed within Montana to determine whether such pesticides are in compliance with the MPA. Pesticides not in compliance may be embargoed if they are:

- ➡ adulterated or misbranded,
- ➡ not registered,
- ➡ fail to bear a proper label,
- ➡ a white powder pesticide and are not colored as required.

Embargoed pesticides cannot be removed, disposed of or sold without MDA permission. Embargoed pesticide products which are brought into compliance with the law will have the embargo removed. If the product cannot meet the provisions of the MPA, it is disposed of at the expense of the claimant.

Special Registrations: The MDA may also register pesticides under Sections 24C and 18 of FIFRA. Section 24C (Special Local Need) and Section 18 (Specific or Emergency Exemption) registrations generally require supplemental labeling. It is the responsibility of the dealer to make sure that this labeling accompanies the product when sold. It is the responsibility of the applicator to have this labeling in his/her possession when the product is applied.

For more detailed information concerning the registration of pesticides refer to sections 80-8-201 through 80-8-202, MCA of the MPA.

Licensing Provisions - *Commercial applicators* are individuals who by contract or for hire apply by aerial, ground, or hand equipment, pesticides to land, plants, seed, animals, waters, structures, or vehicles. Individuals not having financial interest in the business and who are only responsible for the daily mechanical maintenance of pesticide application equipment are not classified as commercial applicators.

A license for commercial applicators is required annually. The license is valid from the date of issuance through December 31 each year. It must be renewed each calendar year BEFORE applying pesticides. Before granting a license, the MDA requires each commercial applicant to provide proof of financial liability, pay a licensing fee of \$75 (fee subject to change in 1999 depending on the Pesticide Disposal Program), and pass the basic examination and specific category examinations with a 70% or better for *general* use pesticides and a 80% or better for *restricted* use pesticides.

- * A *licensed* commercial applicator is a pesticide applicator who has passed the basic examination and specific category examinations with a 70% or better for applying **general** use pesticides.
- * A *certified* commercial applicator is a pesticide applicator who has passed the basic examination and specific category examination with a 80% or better for applying **restricted** use pesticides.

Applicants for a commercial pesticide applicators license shall be required to provide, on forms approved by the MDA, financial responsibility in the form of:

- liability insurance policy,
- surety bond or
- certificate of deposit.

For commercial application of pesticides, the financial responsibility shall be one thousand five hundred dollars (\$1500) for aerial applicators and five hundred dollars (\$500) for ground applicators. Financial responsibility must be maintained throughout the licensing period. Aerial applicators must, in addition, meet all the requirements of the Federal Aviation Agency and the Aeronautics Division of the Montana Department of Transportation before a license is issued. The MDA may also establish licensing and examination requirements for commercial operators by regulation. Commercial applicators are responsible for all pesticide related actions by their employees.

All license holders must recertify every four years. Licensed applicators have the option of recertifying by re-examination or by attending Montana Department of Agriculture (MDA) approved training. Recertification training is available through the MDA on a pre-determined schedule or by attendance at MDA-approved industry sponsored training. All commercial applicators who choose to recertify by training must attend training equivalent to 12 recertification credits (hours) during the recertification period. Commercial pesticide applicators wishing to recertify by examination may contact the MDA in Helena or one of the MDA field offices.

Operators - Employees of licensed or certified applicators using pesticides and not holding their own license must be licensed as an operator. Licensed operators may not apply pesticides beyond one hundred (100) miles of the applicator. The applicator pays a fee of \$25 per operator for the first two applicants and \$10 thereafter, per each additional operator. An operator's license may be obtained in the following ways:

- ◆ pass a MDA examination with a score of 70% or better,
- ◆ attend a MDA training course, or
- ◆ receive training from a certified and/or licensed applicator.

Operators are required to be licensed annually and must be renewed each calendar year BEFORE applying pesticides. They may renew their license by receiving training from a certified and/or licensed applicator or attend a training course approved by MDA and submitting the application fee and application.

Government operators must meet all of the above standards for commercial operators except government operators can only operate within their respective governmental boundaries regardless of the number of miles from the government certified and/or licensed applicator's business location.

Nonresidents - Nonresidents applying for a license in Montana, in addition to meeting the above requirements, must file a written Power of Attorney designating the Secretary of State as their agent. This permits a service of process to be made in the event of suit brought against the nonresident. The Power of Attorney will be written to provide effective jurisdiction by the courts of Montana over the nonresident applicant. Nonresident corporations may appoint a resident agent in lieu of appointing the Secretary of State as their agent.

Government Agencies - Government employees applying pesticides are subject to the provisions of the MPA and its regulations. Supervisors and/or applicators of government sponsored pesticide spray programs will be required to obtain a government applicator license. All applicants for this license will be required to pass an examination. A provision allows a governmental agency to pay the annual applicator's fee of \$75 for each of its first four employee applicators or dealers. The agency shall then pay an annual fee of \$20 for each additional employee applicator or dealer up to a \$600 limit. The license allows the applicator to apply pesticides for agency use only. One licensed applicator or licensed operator is required for each pesticide equipment unit operated by government agencies. Federal agencies are exempt from pesticide applicator license fees.

► Commercial Applicator Licensing Categories

Agricultural Plant Pest Control: An applicator who applies pesticides to an agricultural crop or rangeland. Agricultural Plant Pest applicators must demonstrate practical knowledge of crops grown, their specific pests, and the pesticides used for their control. Practical knowledge is required concerning pesticidal activity in soil and water, pre-harvest intervals, re-entry intervals, phytotoxicity, potential for environmental contamination, non-target injury, and community problems resulting from the use of pesticides in agricultural areas.

Agricultural Animal Pest Control: An applicator who applies pesticides to animals (livestock) or places where animals are confined. Agricultural Animal Pest applicators applying pesticides directly to animals must demonstrate practical knowledge about those animals and their associated pests. A practical knowledge concerning specific pesticide toxicity and residue potential is also required, since host animals are frequently used for food. Further, the applicator must know the relative hazards associated with such factors as pesticide formulation, application techniques, age of animals, stress, and extent of treatment.

Agricultural Vertebrate Pest Control: Vertebrate applicators must demonstrate practical knowledge of vertebrate pests and the pesticides used for their control. They should possess practical knowledge of the cyclic occurrence of certain pests and specific population dynamics as a basis for planning pesticide applications. The applicator must demonstrate a practical knowledge of control and application methods which will minimize the possibility of secondary problems, such as unintended effects on wildlife or hazards to humans, pets, and other domestic animals.

Forest Pest Control: An applicator who applies pesticides to forests, forest nurseries and forest seed producing areas. Forest Pest Control applicators shall demonstrate practical knowledge of the types of forest, forest nurseries, and seed production in Montana and the pests involved. They should possess practical knowledge of the cyclic occurrence of certain pests and specific population dynamics as a basis for planning pesticide applications. A practical knowledge of the beneficial organisms and their vulnerability to the pesticides to be applied is required. Because forest stands may be large and frequently include natural aquatic habitats and harbor wildlife, the consequences of pesticide use may be difficult to assess. The applicator must therefore demonstrate practical knowledge of control methods which will minimize the possibility of secondary problems, such as unintended effects on wildlife. Proper use of specialized equipment must be demonstrated, especially as it may be related to meteorological factors and adjacent land use.

Ornamental & Turf Pest Control: An applicator who applies pesticides to ornamental trees, shrubs, flowers and turf. Ornamental and Turf Pest Control applicators shall demonstrate practical knowledge of pesticide problems associated with the production and maintenance of ornamental trees, shrubs, plantings, and turf. Applicators must understand the potential phytotoxicity as a result of drift and from persistence beyond the intended period of pest

control to a wide variety of plant materials. Because of the frequent proximity of human habitation to application activities, applicators in this classification must demonstrate practical knowledge of application methods which will minimize or prevent hazards to humans, pets, and other domestic animals.

Seed Treatment & Elevator Pest Control: An applicator who applies pesticides or fumigants to seeds or seed storage areas and uses pesticides in or around the elevator seed storage facilities. Applicators in this category must demonstrate practical knowledge of the types of seeds requiring pesticidal protection and application requirements and factors, such as seed coloration, carriers, and surface active agents which influence pesticide binding and may affect germination. They must demonstrate practical knowledge of hazards associated with handling, sorting and mixing, and misuse of treated seed, such as introduction of treated seed into food and feed chains, as well as proper disposal of unused treated seeds. Applicators must be able to demonstrate proper use of grain fumigants to protect seeds, knowledge to assure safe handling, application techniques, worker exposure and protection considerations, and re-entry standards into fumigated structures.

Aquatic Pest Control: An applicator who applies pesticides to any standing or running waters. Applicators in this category must have knowledge of the aquatic environments in which pesticides may be used to maintain or improve the health or desired condition of that environment. They must have practical knowledge concerning potential pesticide effects on plants, fish, birds, beneficial insects, and other organisms which may be present in aquatic environments. Aquatic Pest Control applicators must demonstrate practical knowledge of various water use situations and the potential of downstream effects. Applicators shall demonstrate practical knowledge of the principles of limited area application. Aquatic Pest Control applicators must also demonstrate practical knowledge of the secondary effects which can be caused by improper application rates, incorrect formulations, and faulty application of pesticides used in this classification. To be certified, Aquatic Pest Control applicators must attend a MDA sponsored training program. Persons in this category may be certified as commercial, government or farm (private) applicators.

Right-of-Way Pest Control: An applicator who applies pesticides to public roads, power lines, pipelines or railway right-of-ways. Right-of-Way Pest Control applicators shall demonstrate practical knowledge of a wide variety of environments since rights-of-way can traverse many different terrains, including waterways. They shall demonstrate practical knowledge and ability to recognize target plants. They shall also demonstrate practical knowledge of the nature of herbicides, recognize the need for containment of these pesticides within the right-of-way areas, and understand the impact of their application activities in the adjacent areas and communities.

Public Health Pest Control: An applicator who applies pesticides in public health programs to control pests having medical and public health importance. Public Health Pest Control applicators must demonstrate practical knowledge of vector-disease transmission as it relates to and influences application programs. A wide variety of pests are involved and it is essential

that they be recognized. Life cycles and habitats must be understood to develop control strategies. These applicators shall have practical knowledge of a great variety of environments ranging from stream habitats to those conditions found in buildings. They should also have practical knowledge of the importance and employment of non-chemical control methods, such as sanitation, waste disposal, and drainage.

Demonstration & Research Pest Control: An applicator who demonstrates to the public the proper use of pesticides or an applicator who conducts field research of pesticides. Demonstration and Research Pest Control applicators demonstrating the safe and effective use of pesticides to others will be expected to meet comprehensive standards reflecting a broad spectrum of pesticide use. Many different problem situations will be encountered in the course of activities associated with demonstrations. Practical knowledge of problems, pests, and population levels occurring in each demonstration situation is required. They should demonstrate an understanding of pesticide organism interactions and the importance of integrating pesticide use with other control methods. In general, it would be expected that applicators doing demonstration pest control work possess a practical knowledge of all the standards detailed in the Montana Pesticide Act - Administrative Rules of Montana (ARM) 4.10.204. In addition, they shall meet the specific standards required for classifications a through g of ARM 4.10.205 applicable to their particular activity. Persons conducting field research or method improvement work with restricted use pesticides are expected to know the general standards required for classifications a through j of ARM 4.10.205, applicable to their particular activity, or alternatively, to meet the more inclusive requirements listed under "Demonstration".

Industrial, Institutional, Structural and Health-Related Pest Control (PCO): An applicator who applies pesticides in, on or around food handling and manufacturing establishments, human dwellings, institutions, industrial establishments, including warehouses and any other structures and adjacent areas, for the protection of stored, processed or manufactured products. These applicators must demonstrate a practical knowledge of a wide variety of pests and their life cycles, types of formulations appropriate for their control, and methods of application that avoid contamination of food, damage and contamination of habitat and exposure of people and pets. Since human exposure includes babies, children, pregnant women, and elderly people, applicators must demonstrate practical knowledge of the specific factors which may lead to hazardous conditions for these individuals, including continuous exposure in the various situations encountered in this classification. Because health-related pest control may also involve outdoor applications, applicators must demonstrate practical knowledge of environmental conditions particularly related to this activity.

Wood Product Pest Control: Any applicator using pesticides to preserve wood. Wood Product Pest Control applicators must demonstrate practical knowledge of the specific wood preservative products used in their operation (creosote, pentachlorophenol, inorganic arsenicals, copper naphthenate). They shall be knowledgeable about the protective clothing

and equipment requirements, as well as the requirements for proper care and disposal of work clothing and equipment. They must be aware of the prohibitions against eating, drinking and smoking and other potential avenues of worker exposure while applying wood preservative chemicals. Applicators must demonstrate practical knowledge of application techniques which prevent direct exposure to domestic animals and livestock and prevent contamination of food, feed or drinking and irrigation water by such pesticide applications. They must demonstrate practical knowledge of hazards of handling treated products as well as the requirements for proper disposal of pesticide waste. They must be familiar with the Consumer Awareness Program (CAP) which is implemented through the use of Consumer Information Sheets (CIS's) provided to the end users of such treated products (the consuming public).

Livestock Protection Collar (LPC): Livestock Protection Collar applicators are certified to apply collars containing sodium monofluoroacetate (Compound 1080) to sheep for the control of coyotes that prey on domestic sheep. The LPC, placed on the throat of sheep, targets predatory coyotes by keying on their tendency to attack prey at the throat and puncturing the LPC in the process. To be certified, applicators must attend specific training on the LPC and, by field demonstration and examination, demonstrate a knowledge of predator biology and identification, alternative methods of coyote control, sheep management, safety practices in handling Compound 1080, nontarget wildlife hazards, and the protection of endangered species. Persons in this category may be certified as commercial, government or farm (private) applicators.

Sodium Cyanide (M-44): M-44 applicators are certified to used sodium cyanide in the M-44 device for the control of coyotes, fox and wild dogs that prey on livestock and poultry. Capsules containing sodium cyanide are used in a spring operated mechanism called an M-44 device. The sodium cyanide is ejected into the mouth of a coyote when the coyote bites and pulls on the device, releasing a spring powered plunger. To be come certified, applicators must attend specific MDA training on the M-44 device; and through field demonstration and examination, demonstrate a knowledge of predator biology and identification, alternative methods of coyote control, livestock management, safety practices in handling sodium cyanide, nontarget wildlife hazards and the protection of endangered species. Persons in this category may be certified as commercial, government or farm (private) applicators.

Special Utility: Special Utility applicators are persons employed by a utility company who apply wood preservation pesticides using pole wraps or conduct weed control using soil sterilants or herbicides on property or rights-of-way owned or managed by the utility company. Applicators in this category must demonstrate a knowledge of commonly used wood treatment products and their use in pole wraps. They shall also have knowledge of personal protective clothing and equipment, methods and procedures to prevent the off site movement of wood preservatives and soil sterilants, particularly by runoff in surface water and leaching to ground water, and practical knowledge of disposal of waste pesticides and containers.

School Pest Control (School IPM): School Pest Control applicators include any applicators using or supervising the use of pesticides in the school environment including but not limited to school yards, buildings, playing fields, and other property under the jurisdiction of the school district. School Pest Control applicators must demonstrate a practical knowledge in the principles of integrated pest management (IPM) and a knowledge of pesticides registered for use in the school environment, in addition to the knowledge required by applicators in the Industrial, Institutional, Structural, and Health-Related category.

Regulatory Pest Control: Regulatory pest control applicators shall demonstrate practical knowledge of regulated pests, applicable laws relating to quarantine and other regulation of pests, and the potential impact on the environment of pesticides used in suppression and eradication programs. Factors which influence introduction, spread, and population dynamics of relevant pests must be understood. In the case of some federal agency applicators, their knowledge shall extend beyond that required by their immediate duties since their services are frequently required in other areas of the country where emergency measures are invoked to control regulated pests, and where individual judgments must be made in new situations.

Regulatory Pest Control - Mosquito Abatement: A governmental applicator who applies pesticides to control mosquitos.

Regulatory Pest Control - Predator: A governmental applicator who applies pesticides to control predators for the protection of domestic livestock or endangered species.

Regulatory Pest Control - Quarantine: A governmental applicator who applies pesticides to control vectors of diseases that affect the public health.

Regulatory Pest Control - Rodent: A governmental applicator who applies pesticides for the control of field rodents on publicly owned property.

Regulatory Pest Control - Weed: A governmental applicator who applies pesticides to public roadways or right-of-ways for the control of weeds.

Dealer Licensing - The MPA requires that all pesticide dealer outlets have an individual licensed to sell pesticides in Montana. Pesticide sales and field personnel not under the supervision of a dealer must also be licensed. Dealers are required to pass an examination with a score of 75% or better before a license is granted. To become licensed, dealers must submit an application to the MDA with a \$75 licensing fee (fee subject to change in 1999 depending on the Pesticide Disposal Program) each calendar year. It is a violation of the Montana Pesticides Act for a dealer or his/her employees to sell pesticides prior to becoming licensed.

Retail Sale of Pesticides: Retailers may only sell pesticides which are designated for use for home, yard, gardens and lawns. The MDA has restricted retail sales of pesticides to those products which do not exceed specified quantities, in gallons or pounds, and those having a concentration considered sublethal to humans or animals.

Farm (private) Applicator Licensing - Farm (private) applicators who need to use a restricted use pesticide on their own property for an agricultural use must obtain a license (permit) from the Extension Service. To obtain a permit, farm applicators must pass a Farm Applicator Exam or attend a training course and complete an ungraded quiz. Farm (private) applicators must follow federal record keeping required by the USDA for restricted use pesticides. A farm (private) applicator does not require a commercial applicator license when he/she:

- 1) applies general use pesticides to his/her own land,
- 2) is not engaged in the business of applying pesticides for hire, and
- 3) operates his/her equipment only in the vicinity of his/her own property.

The farm (private) applicator permit is issued for 5 calendar years and the fee for the permit is \$50 (fee subject to change in 1999 depending on the Pesticide Disposal Program).

Revocation of License - The MDA may refuse to grant, or renew, or may revoke a license or permit when the MDA has determined that the licensee or holder of the permit is not qualified to use or apply pesticides, is determined to be legally blind, or has committed any of the following:

- Made false or fraudulent claims, misrepresenting the effect of materials or methods to be utilized,
- Applied illegal materials,
- Operated in a faulty or careless or negligent manner,
- Operated faulty or unsafe equipment,
- Refused or neglected to comply with provisions of FIFRA or the MPA,
- Used or applied a registered pesticide inconsistent with its label or labeling,
- Refused or neglected to keep and maintain application records,
- Made false or fraudulent records or reports,
- Operated equipment without a permit or license, or
- Used fraud or misrepresentation in making application for license or permit or renewal of a license or a permit.

Decisions of the MDA relating to issuance or revocation of licenses or permits may be appealed.

Report of Loss or Damage - A person suffering loss or damage resulting from the use or application of any pesticide by any person shall, within 30 days from the time the occurrence of the loss became known to him/her, file with the MDA a verified report of loss. Refer to section 80-8-301, MCA of the Pesticide Act for a full description of requirements.

♦ Administrative Procedures

Rules and Regulations The MDA has the authority to adopt by reference, without a public hearing, regulations adopted under FIFRA. The MDA may also, after public hearing, adopt rules and regulations necessary to carry out the provisions of the MPA.

Emergency Power - The MDA may declare an emergency when an event exists that requires immediate action with regard to the registration, use or application of pesticides. The Director may, without notice or hearing, issue necessary orders to protect the public from adverse affects of pesticides. The emergency period may not exceed the time prescribed by the Montana Administrative

Procedure Act. However, in this period of time, a regulation may be passed to control the pesticide following the emergency period.

Public Hearings - The MDA must hold a public hearing when adopting new rules and regulations, except when adopting federal regulations. Specific procedures for rule making and hearing functions shall be conducted in accordance with the Montana Administrative Procedure Act.

Public Information - The MDA may publish or make available information on the registration, use and sale of pesticides in Montana, provided that such information will NOT disclose such operations as selling, production or use of pesticides by any person.

Investigation and Enforcement Authority - The MDA, upon reasonable cause, has the authority to enter upon private and public premises and property, at reasonable times, with a warrant or consent of the owner to inspect or investigate:

- Equipment,
- Actual or reported adverse effects caused by pesticides in humans, crops, animals, land or other property,
- Records on the selling or use of pesticides and the person's stock of pesticides,
- Storage and disposal of pesticides,
- Sample pesticides being applied or to be applied,
- The use and application of a pesticide,
- The environment alleged to have been exposed to pesticides and to collect and analyze environmental samples,
- Compliance with pesticide Worker Protection Standards and labeling, including handlers and workers,
- Compliance with pesticide groundwater and Environmental Protection Agency endangered species standards and labeling, and
- Compliance with licensing, labeling, permitting, and certification requirements.

The MDA is authorized to investigate all incidents involving the application, sale, introduction, or use of registered pesticides or compounds capable of acting in the manner of pesticides when the incidents have a reasonable potential to adversely affect the public environment or persons. The investigation or inspection authority provided for in this section may be exercised over persons not possessing a required license or permit.

Violations - Applicators must follow all federal and state laws, regulations, labels, and record keeping requirements. Failure to do so constitutes a federal, state or federal and state violation. Violations may be subject to penalties, both civil and criminal. Any person convicted of violating provisions of the MPA and its regulations is guilty of a misdemeanor. Temporary and permanent injunctions may be obtained to restrain individuals from violating or continuing to violate any provisions of the MPA. The MDA also has the authority to initiate civil penalties. In considering significance of a major violation and assessing civil penalties, the MDA will consider all the circumstances surrounding the violation and the degree of care which was implemented.

► **Montana Agricultural Chemical Ground Water Protection Act (MACGWP)**

The Montana Agricultural Chemical Ground Water Protection Act, Title 80, Chapter 15, MCA is administered jointly by the Departments of Agriculture and Environmental Quality. This law establishes Montana policy protecting water resources and the use of agricultural chemicals. Both agencies will:

- protect ground water and the environment from impairment or degradation due to the use of agricultural chemicals;
- ensure that agricultural chemicals are properly and correctly used;
- provide management of agricultural chemicals which will prevent, minimize and mitigate their presence in ground water; and
- provide education and training of agricultural chemical applicators and the general public on ground water protection, agricultural chemical use, and the use of alternative agricultural methods.

Water Quality Standards - The Department of Environmental Quality (DEQ) is responsible for the adoption of ground water quality standards for agricultural chemicals for which federal standards exist and for those agricultural chemicals whose presence has been verified in ground water. Upon request from the MDA, DEQ shall develop or request EPA to develop a standard for agricultural chemicals for which there is no existing standard. Water quality standards are used by both agencies in assessing potential threats to human health from consumption of contaminated ground water.

Monitoring - Both the MDA and DEQ are required to conduct monitoring of ground water resources to determine:

- 1) whether residues of agricultural chemicals are present in ground water, and
- 2) the likelihood of an agricultural chemical entering ground water, based on sufficient valid scientific data to reasonably predict the behavior of a particular agricultural chemical in the soil.

Both the MDA and the DEQ review and evaluate monitoring and sampling data jointly. The departments, in cooperation, determine the appropriate response to contamination. Such determinations are based upon water quality standards, water classification (i.e. how the water is used) and risk to human health, based on consumption patterns.

Management Plans - The MDA is responsible for the development of management plans which provide for the protection of ground water resources through the management of agricultural chemicals. The MDA published the Montana General Agricultural Chemical Ground Water Management Plan (GMP) in 1994.

The GMP sets the basis upon which all state specific management plans are based on. Specific management plans will be developed and implemented when any of the following conditions occur:

- The level of an agricultural chemical in ground water is at or above 50% of the standard;
- A definite trend of increased presence of an agricultural chemical in ground water is scientifically validated;

- An agricultural chemical has been determined to have migrated in the ground water from the point of detection;
- EPA proposes to suspend or cancel registration, prohibits or restricts the sale or use in the state, or otherwise initiates action against an agricultural chemical because of ground water concerns and when EPA's action, restriction, or prohibition will be implemented unless the state develops an adequate management plan; or
- An agricultural chemical possesses properties that indicate it has the potential to migrate to ground water and it is being applied on areas with vulnerable ground water.

All management plans will be specific to the agricultural chemical in question and will be geographically defined. The MDA must consider the current and potential beneficial use or uses of the ground water included in or affected by the plans. The MDA must also consider the benefits of appropriate agricultural chemical use when developing any management plan.

All plans will have, at a minimum, 1) requirements to prevent ground water impairment that are based on ground water use, value and vulnerability and which address all applicable aspects of the chemical use; and 2) requirements to prevent or minimize further presence of the agricultural chemical in ground water that provides for the protection of the current and future beneficial use of the ground water.

Management plans may also include any of the following elements:

- geographical use restrictions;
- ground water and environmental characterization;
- best management plans and practices;
- identification of high priority ground water;
- certification, licensing, training and education requirements for pesticide applicators;
- identification of application setback areas around water wells where activity restrictions may be implemented;
- agricultural chemical application rates and timing use restrictions;
- alternative pest management techniques;
- alternative soil fertility practices; and
- EPA requirements.

All management plans must be adopted as administrative rules and are enforceable under the Montana Ground Water Act.

Commercial Fertilizer Ground Water Management Plans - If the MDA or the DEQ determine that residues from commercial fertilizer are present in the ground water or when EPA implements a program to protect ground water from fertilizers, a commercial fertilizer ground water management plan may be developed.

Enforcement and Investigations - The MDA has the authority to:

- investigate conditions relating to compliance with agricultural chemical labels, management plans, monitoring requirements, ground water protection requirements and to investigate violations of plans or compliance orders;

- gain access to and copy any records required by the MDA;
- establish and inspect monitoring equipment; and
- sample ground water or soil.

The MDA may issue a compliance order to any person(s) violating a standard or any other requirement of the MACGWPA. The MDA may require cleanup of any agricultural chemical that has been accidentally or purposely dumped, spilled, misused or unlawfully used that has contaminated or has a significant probability of entering ground water.

Administrative Civil Penalties - Persons violating the MACGWPA may be assessed an administrative civil penalty of up to \$1,000 for each offense for commercial applicators and up to \$500 for farm (private) applicators. Assessment of a civil penalty may be made in conjunction with any other warning, order, or administrative action. When determining an appropriate administrative civil penalty, the MDA shall consider the effect of the person's ability to continue in business, the gravity of the violation that occurred, the degree of care exercised by the offender, and whether significant harm resulted to public health, agricultural crops, livestock, or the environment.

Judicial Civil Penalties - Persons who unlawfully violate any order, specific agricultural chemical ground water management plan or any provision of MACGWPA shall be subject to a judicial civil penalty not to exceed \$10,000. Each occurrence constitutes a separate violation.

Criminal Penalties - Violations of the MACGWPA committed intentionally by any person(s) are subject to a fine up to \$25,000 for each day the violation continues or imprisonment for up to 1 year or both. Following an initial conviction under this section, a subsequent conviction subjects a person to a fine of not more than \$50,000 for each day the violation continues or imprisonment for not more than 2 years, or both.

♦ **Montana Water Quality Act (MWQA)**

The Montana Water Quality Act (MWQA) is administered by the DEQ. The purpose of this Act is to provide additional and cumulative remedies to prevent, abate, and control the pollution of state waters. MWQA outlines the responsibilities of the DEQ in the development of water quality standards, water resource use and quality classifications, and non-degradation rules as they relate to surface and ground water resources of Montana. Also contained within the MWQA are the Emergency Powers of the DEQ (ARM 16.20.1025) which contain the procedures that must be followed when there are spills or unanticipated discharges of pesticides or other toxic substances that would lower the quality of any ground waters of the state below Montana ground water quality standards. Under the Water Quality Act, it is unlawful to pollute any state waters, or to place or cause to be placed any wastes, in a location where they will cause pollution of state waters.

♦ **Montana Food, Drug and Cosmetic Act**

The Miller Amendment (1954) of The Montana Food, Drug and Cosmetic Act requires that any raw agricultural commodity be condemned as adulterated if it contains pesticides for which there is no established tolerance or for which established tolerance limits are exceeded.

► **Montana Solid Waste Laws**

The Montana Solid Waste Management Act prohibits the disposal of any solid waste in any location not licensed as a solid waste disposal site by the DEQ. Refuse is defined as "all putrescible and non-putrescible solid industrial wastes." In this context, some pesticides are included within the definition. Any person found violating this act is guilty of a misdemeanor.

CHAPTER II

PESTICIDE RECORD KEEPING

Applicator and dealer records of pesticide sales and use are important to provide a history of your operation. Meaningful records will also serve to protect your business and assist in evaluating expenses, profits, and in maintaining an inventory.

There are many different record keeping systems which may be used by applicators and dealers. These systems may range from field notes and records, to office sales, use and inventory records, to the use of computerized records.

► Dealer Records

The Montana Pesticides Act - Administrative Rules of Montana (ARM) 4.10.504 requires the following for dealers:

All pesticide dealers, including pharmacists, veterinarians, and certified pharmacies are required to maintain shipping, purchase or invoice records of all pesticide products received. A complete and accurate record of all restricted use pesticides purchased and sold also must be maintained. All records must be kept for two (2) years.

Each sale of a restricted use pesticide for the records must include:

- the company name on the label;
- the complete trade name or the EPA registration number;
- the volume sold;
- the license or permit number of the certified applicator or dealer;
- the date; and
- the name of the certified applicator or purchaser.

► Dealer Pesticide Reports

Beginning in 1990, each dealer selling general and restricted use pesticides must submit a summary report to the MDA containing the above information every fifth year. The summary report will be for that one year only and is due by January 31 of the following calendar year. For example, sale records will be required for the year 2000. Those records will be due January 31, 2001. Standard forms provided or approved by the MDA must be used to submit the report. If no restricted or general use pesticides are sold during the time period requested by the MDA, that must be documented to the MDA.

Sales of retail pesticides are exempt from the record keeping and reporting requirements of this rule. For further information on records of retail pesticides can be found in ARM 4.10.502 (2).

Records required by dealers, pharmacists, veterinarians, and certified pharmacies are subject to inspection by authorized employees of the MDA during normal business hours. Dealers are required to submit the records (a copy or the original) to the MDA upon written request.

► **Applicator Records**

The Montana Pesticide Act - Administrative Rules of Montana (ARM) 4.10.207 requires the following for applicators:

All licensed, certified-licensed, commercial, public utility, government applicators, and certified non-commercial applicators are required to keep and maintain operational records for two (2) years. A record must be kept of every application performed by either an applicator or operator and must include:

- The name of the **applicator** or employee applying the pesticide.
- The **date** of application.
- The **time** of application (be specific).
- The **location** must include the property owner's or lessee's name and address,
- The **county or counties** where the pesticide was applied, and specific application site (township, range and section number) or local identifiable landmarks. Right-of-way and similar applications may reference identifiable landmarks.
- The **equipment** used: the same piece of equipment may be listed once and thereafter referenced. If more than one piece of equipment is used, they may be listed once by description and then by number.
- The **pesticide(s)** used, with the company or manufacturer's name, trade name, the EPA registration number or type of formulation.
- The **rate** of application used, including the amount of diluent sprayed on an area (example: 1 pint of product/5 gallons of water per acre).
- The size of **area** treated (acres, trees, livestock, square feet or yards, etc.) or for structural, seed, or wood product applications, the type of treatment.
- The primary **pest(s)** involved (do not use general terms, such as weeds and bugs).
- The **crop** or site treated and the stage of crop development, if applicable.
- The **weather** conditions, such as the temperature, wind velocity and direction.

Seed treaters and wood product treaters are only required to maintain records on the volumes of pesticides applied and the following must also be included in the records:

- The name of the **applicator** or employee applying the pesticide.
- The **date** of application.
- The **pesticide(s)** used with the company or manufacturer's name, trade name, the EPA registration number and type of formulation.
- The **rate** of application used.
- The **volume** applied.
- The **type** of treatment used.

Applicators using two or more pesticides in a tank mixture must record all data as required for each pesticide in the tank mix. Application records must be completed within 24 hours of the actual pesticide application.

Applicator records are open to inspection by authorized employees of the MDA during all business hours. Applicators are required to submit copies of their records or any portion of the records when requested, in writing, by the MDA.

♦ **Applicator Pesticide Reports**

The MDA requires applicators to submit an accurate report of their use of restricted and general classified pesticide use every fifth year, beginning in 1990. Required reports will be for that year only and must include a summary of pesticide use by:

- ◆ county,
- ◆ month,
- ◆ total acreage,
- ◆ amount of the product used,
- ◆ crop or site treated,
- ◆ the company name and trade name of product(s) used, and
- ◆ the EPA registration number or the type of formulation.

Reports need to be submitted to the MDA by January 31 of the following year. Standard forms provided or approved by the MDA must be used to submit the report. If no application of general and/or restricted use pesticides are made during the fifth calendar year, that will also need to be documented to the MDA by the January 31 due date.

Farm (private) applicators are exempt from the record keeping requirements by the State of Montana except for those applicators licensed in aquatic, M-44, and 1080 collar categories. However, the USDA does require farm applicators to keep records of restricted use pesticides for at least two years. These records include applicator name and license number, product/trade name, EPA registration number, amount applied, crop sprayed, size of site, date, and specific location.

♦ **Incident Reports**

An applicator who, through his/her own actions or omissions, or the actions or omissions of his/her employees, causes or allows any pesticide to drift, run off or otherwise escape onto another person or property must file a written report to the MDA within forty-eight (48) hours of the incident. The report will include:

- ◆ specific location of the incident,
- ◆ name of the pesticide involved,
- ◆ type of formulation,
- ◆ method of application, and
- ◆ name and address of the person whose land, person or property was subjected to the unintentional pesticide application.

In addition, if the pesticide is classified as either Extremely Toxic or Highly Toxic to people or animals, the applicator or operator must immediately stop his/her application and notify the landowner whose land, person, or property was subjected to unintentional pesticide application and immediately notify the MDA.

♦ Notification by Applicators

Applicators applying EPA restricted pesticides shall notify the owner, lessee or manager of the property of all precautions and restrictions before applying the restricted use pesticide. The applicator, if requested, is required to provide a copy of the label to the owner, manager or lessee. Applicators applying EPA restricted pesticides in an easement or right-of-way situation are not required to notify any person if the applicator is employed by or specifically contracted by the person holding or managing the easement or right-of-way.

CHAPTER III

WORKER PROTECTION STANDARD (WPS)



In 1992 the EPA revised the Worker Protection Standard (WPS) for agricultural pesticides. The standard is designed to limit farm workers' exposure to pesticides, reduce adverse health affects when exposure occurs, and educate workers about the hazards associated with occupational pesticide use.

The standard affects anyone who uses pesticides in the production of agricultural plants on farms, forests, nurseries and greenhouses. Owners and operators of these work sites, whether they employ a part-time person to hundreds of employees, must comply with all provisions. Owners, including farmers and their immediate families, are exempt from some of the requirements; however, they must comply with worker protection requirements specified by pesticide labels.

The WPS was revised in August of 1992 and gradually implemented over the next 3 years. It became fully effective January 1, 1995. After October 23, 1995, no agricultural use pesticides may be sold without the proper WPS labeling. Today everyone covered by the WPS must be in complete compliance.

♦ WPS Terminology

Agricultural Worker - Anyone who performs tasks related to cultivation and harvesting of plants on farms or in greenhouses, nurseries, or forests.

Pesticide Handler - Anyone who mixes, loads or applies crop chemicals, or who cleans, adjusts and repairs contaminated equipment; flags and assists with application and performs a few other specialized jobs.

Personal Protective Equipment (PPE) - Specific protective garments required by the pesticide label to apply the pesticide or for early entry activities.

Restricted Entry Intervals (REI) - The period of time worker entry is restricted after application of a pesticide. REI's can range from 4 hours for some low risk pesticides to 72 hours.

Immediate Family - Includes spouse, children, stepchildren, foster children, parents, stepparents, foster parents, brothers, and sisters.

► **The Worker Protection Standard Goals**

The WPS uses three approaches to promote safe pesticide handling and application:

- ***Eliminating or Reducing Pesticide Exposure*** - Restricted-entry intervals (REI'S) have been established for all agricultural pesticides. REI'S on the pesticide label inform the employer how many hours must pass before agriculture workers can enter a treated site. Early-entry handlers and workers must wear the personal protective equipment (PPE) listed in the Agricultural Use Requirements box on the pesticide label.
- ***Minimizing Damage if Exposure Occurs*** - Employers must supply pesticide handlers and agricultural workers with an ample supply of water, soap, and towels for routine washing. The employer must make transportation available to a medical care facility and provide information about the pesticide(s) to which the worker or handler may have been exposed.
- ***Informing Employees About Pesticide Hazards*** - All agricultural workers are to receive pesticide safety training and have access to a pesticide safety poster. Pesticide handlers must be informed about label safety information and a centrally located listing of recent pesticide treatments must be posted on the establishment.

► **Pesticide Labeling**

Agricultural pesticides covered by WPS will have a "Agricultural Use Requirements" statement in the "Directions for Use" section of the pesticide labeling on REI'S and PPE for that product. The

example at left is: dicamba sodium salt (Banvel SGF Herbicide)

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard 40 CFR part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on the label about personal protective equipment (PPE), and restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 12 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involved contact with anything that has been treated such as plants, soil, or water, is:

Coveralls
Waterproof gloves
Shoes plus socks
Protective eyewear

The Code of Federal Regulations (CFR) is a codification of the general and permanent rules published in the Federal Register by the Executive departments and agencies of the Federal Government. Title 40 CFR Part 170 (WPS) contains a standard designed to reduce the risks of illness or injury when using pesticides. The *How to Comply* manual published by the EPA condenses the information in the CFR to help the employer,

handler, worker, etc. understand and comply with the WPS. The *How to Comply* manual is available through various agricultural safety equipment catalogs, from the local County Extension Offices, and Montana Department of Agriculture (MDA).

► **Employer's Responsibilities**

- ✓ *Information at a Central Location* - The following information must be centrally located and easily seen:



Pesticide Application List-

- ◆ location and description of the area to be treated,
- ◆ product name, EPA registration number, and active ingredient(s) of the pesticide,
- ◆ time and date the pesticide is scheduled to be applied, and
- ◆ restricted-entry interval for the pesticide.

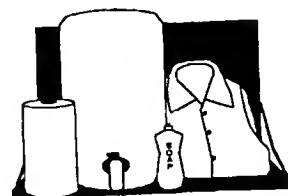
Emergency information and telephone numbers.

A pesticide safety poster.

- ✓ *Pesticide Safety Training* - Each pesticide handler and agricultural worker must be trained in general pesticide safety and will be issued an EPA-approved training card. The EPA handler and worker cards are valid for 5 years and must be carried by pesticide handlers and agricultural workers while on the job site.
- ✓ *Decontamination Sites* - Establish a decontamination site within 1/4 mile of all agricultural workers and pesticide handlers. Decontamination sites must provide the following:

Agricultural Worker decontamination sites

- ◆ Water - enough for routine washing and emergency eye flushing; at least **one gallon** for each worker.
- ◆ Soap and single-use towels.



Pesticide Handler decontamination sites

- ◆ Water - enough water for washing the entire body in case of emergency; at least **three gallons** for each handler.
- ◆ Soap and single-use towels.
- ◆ Clean change of clothes, such as one-size-fits-all coveralls

- ✓ *Employer Information Exchange* - Before any application, the **commercial applicator** must make sure the employer is aware of the following information about the pesticide(s) applied:
 - ◆ location and description of area to be treated,
 - ◆ time and date of application,
 - ◆ product name, EPA registration number, active ingredient(s), and REI,
 - ◆ if the product label requires both oral warnings and treated area posting, and
 - ◆ all other safety requirements on labeling for workers or other people.

Before any application, the **employer** must make sure the commercial applicator is aware of the following information:

- ◆ specific location and description of all areas where pesticides were applied,
- ◆ where a REI is in effect, and
- ◆ restrictions on entering those areas.

- ✓ *Emergency Assistance* - When any pesticide handler or agriculture worker who may have been injured by pesticide(s) needs to be promptly transported to an appropriate medical facility and the following information made available to the medical personnel:
 - ◆ product name, EPA registration number, and active ingredient(s),
 - ◆ all first aid and medical information from the pesticide label,
 - ◆ description of how the pesticide was used, and
 - ◆ information about the victim's exposure.
- ✓ *Anti-retaliation* - Employers are prohibited from retaliating against a worker or handler who attempts to comply with the WPS.

► **Regulation of the WPS**

In Montana, WPS is enforced by the MDA. The Field Services Bureau of the Agricultural Sciences Division has seven inspectors throughout the state who enforce this federal law. Routine inspections and compliance assistance inspections are conducted to ensure that those who are covered by the WPS are in compliance. They investigate all pesticide exposure complaints. If it is found that an employer is not complying with the WPS, appropriate enforcement actions may be initiated by the MDA. Enforcement actions will vary from a Notice of Violation or warnings for minor violations, such as not having a safety poster, to civil penalties for serious violations, such as not providing emergency assistance when an individual has been exposed to pesticides.

CHAPTER IV

THE PESTICIDE LABEL

FIFRA requires specific information to be printed on the container labels of registered pesticides. This provision is made to provide instructions for the proper and consistent use of pesticides by applicators. The **label** is any information written, printed or graphic matter on or attached to the pesticide or device or any of its containers or wrappers printed on or attached to a pesticide container.

Labeling refers to all written, printed or graphic matter information about the pesticide provided by the manufacturer, including the label and supplemental literature, such as leaflets, flyers, and pamphlets accompanying the pesticide or device at any time.

Occasionally, revised labels are sent out to replace the label attached to the container. Legally, any labels must be in your possession at the time of application. *The label is a legal document and must be followed.* Failure to do so may result in the assessment of civil or criminal penalties. By reading the label carefully and following label directions, misuse of the pesticide is less likely and potential injury to people, animals, or the environment is reduced. The most valuable time spent in pest control is the time taken to read and follow the label.

The importance of reading the label cannot be over stressed. Labels are placed on pesticide containers for the applicator's information and protection. If the label is read and understood prior to purchase or use of a pesticide, the possibility of a pesticide accident occurring is minimized.

The pesticide label is the final result of a registration process and reflects the risks and benefits of a given pesticide to the user. Industry spends several million dollars on research to develop a label for a single pesticide product before that product is ever marketed. Because of this expense, the registrant has a significant economic stake in seeing that the product is used as the label directs, both to ensure the product is effective and that there are no adverse effects as a result of its use. Therefore, pesticides have labels with specific instructions in terms of safety, storage, disposal, and use.

► Reading The Label

 *Before buying a pesticide, read the label to determine:*

- ◆ whether it will control the identified pest of concern,
- ◆ whether the pesticide can be used safely under the application conditions anticipated (site, climate, equipment, etc.),
- ◆ where the pesticide can be used (on specific crops, on turf, in water, etc.),
- ◆ how much pesticide to buy for the area being treating in order to prevent a surplus, and
- ◆ personal protective equipment (PPE) requirements.

 Before mixing the pesticide, read the label to determine:

- ◆ what protective clothing should be worn,
- ◆ compatibility with other pesticides or products,
- ◆ how much pesticide to prepare, and
- ◆ the mixing procedure.

 Before applying the pesticide, read the label to determine:

- ◆ what safety equipment is required,
- ◆ when to apply the pesticide,
- ◆ how to correctly apply the pesticide,
- ◆ whether there are any restrictions on the use of the pesticide that must be considered, and
- ◆ if application can be made without violating designated re-entry, harvest, grazing or re-cropping intervals.

 Before storing or disposing of the pesticide or pesticide container, read the label to determine:

- ◆ where and how to store the pesticide,
- ◆ how to dispose of any surplus pesticide, and
- ◆ how to clean and dispose of the pesticide container.

Format of Labels

FIFRA establishes the regulations for formatting the pesticide labels and prescribes what information they must contain. All pesticide products have a consistent label format. FIFRA requires that certain statements appear on specific locations on the pesticide label. This provides the reader with ready access to specific information and increases the understanding of the proper use of pesticides. Some packages are too small to have all of the necessary information printed on them, so manufacturers may attach supplemental labels to containers, often enclosed in a plastic pouch and glued to the side of the container. Paper packages may have supplemental labels inserted under the bottom flaps.

See Figures 1 (page 36) and 2 (page 37) to locate the numbers on the generic labels.

1 Restricted and General Use Statements

A **restricted use** pesticide label identifies its classification with a restricted use statement. The restricted use statement must appear at the top of the front panel. Any pesticide classified for general use on certain crops and restricted use on others must be labeled separately. The primary difference between the General Use and Restricted Use Pesticide labels is the presence of the "Restricted Use Pesticide" block at the top of the center panel. Use of products with a restricted use label requires certification for both private and commercial applicators.

A [1a] **general use** pesticide does not have the "Restricted Use Pesticide" block at the top of the label and may or may not be labeled with the words "General Classification" below the heading "Directions for Use".

2 Trade Name or Product Name

A trade/product name is the name the manufacturer has given to the product and is the name used for advertising and promotion purposes. Examples: Tordon 22K, Roundup, Assert, Dursban, etc.

3 Ingredients

Pesticide labels list the percentage of active and inert ingredients by weight. [3a] **Active Ingredients** are the part of the pesticide which will kill pests or prevent damage by them. The [3b] **Common Name** is a well-known, simple name of a pesticide accepted by the Pesticide Regulation Division of the EPA and will be after the words "Active Ingredients". For example, Tordon 22K has a common name of *picloram* and Roundup has a common name of *glyphosate*. However, common names and trade/product names may not be the same. Occasionally, a chemical name may not have a common name. [3c] **Chemical Names** describe the chemical structure of a pesticide and are derived by chemists based on international rules for naming chemicals. The chemical name(s) will be after the common name and are comprised of the active ingredient(s) and are often complex. Examples: 4-amino-3,5,6-trichloropicolinic acid is Tordon's chemical name and 2,4-dichlorophenoxyacetic acid is 2,4-D Amine's chemical name. [3d] **Inert Ingredients** are all components of the formulation that do not have pesticidal action. They may be totally harmless or they may have toxic, flammable, or other characteristics that may pose other safety or environmental problems.

If a pesticide contains more than one active ingredient, the percentage of each will be given. Inert ingredients need not be listed separate or specific and may be grouped together.

Example: Curtail label

Active Ingredients:

Clopyralid: (common name)

(chemical name) 3,6-dichloro-2-pyridinecarboxylic acid, monoethanolamine salt 7.5%

(chemical name) 2,4-dichlorophenoxyacetic acid, triisopropanolamine salt 38.4%

Inert Ingredients 54.1%

TOTAL 100.0%

A [3e] **pound per gallon** statement will appear directly below the main ingredient statement if the product is *liquid*. However, this example of an Ally label is a dry flowable product and does not have this statement.

4 **KEEP OUT OF REACH OF CHILDREN** is required on each pesticide label regardless of classification or toxicity. [See Chapter VIII - Toxicology of Pesticides]

5 Signal Word and Toxicity Classification

An important part of every label is the signal word. The word "Danger" accompanied by the word "Poison" and a skull and crossbones, or the word "Danger" used alone indicates that the pesticide is highly toxic or poses a dangerous health or environmental hazard (Toxicity Category I). If a pesticide is assigned to Category I on the basis of its oral, dermal, or inhalation toxicity, the word "Poison" and the skull and crossbones must appear in close proximity to the signal word. "Warning" indicates moderate toxicity (Toxicity Category II) and "Caution" means low toxicity (Toxicity Category III). Part of the registration process assigns each pesticide to a toxicity category and prescribes which signal word must be used on the label.

Pesticides are classified into four broad categories of toxicity. Specific signal words give an indication of the toxicity of that product to humans.

- A **category I** pesticide is identified by the signal word "**DANGER or DANGER - POISON.**" These pesticides may cause toxic effects on contact with the skin or may be extremely corrosive to skin and eyes. The following table indicates that category I pesticides are the most toxic if swallowed. It takes just a taste to a teaspoonful of some category I products to be lethal. Example: Parathion
- A **category II** pesticide is identified by the signal word "**WARNING.**" A lethal dose is approximately a teaspoon to a tablespoon of a pesticide. Example: Diazinon
- A **category III** pesticide is identified by the signal word "**CAUTION.**" A lethal oral dose is one tablespoon to a pint. Example: Tordon
- A **category IV** pesticide must bear on the front panel the signal word "**CAUTION**". The LD₅₀ is the determining factor between category III and IV. Example: Dial Antibacterial Kitchen Cleaner

| SIGNAL WORD | TOXICITY CATEGORY | LD ₅₀ <small>LD₅₀ is the amount of pesticide, measured in milligrams per kilogram (mg/kg) of body weight, that will kill one-half of the exposed population</small> | | |
|---|----------------------------------|--|-----------------------|----------------|
| | | Oral | common measuring unit | Dermal |
| DANGER - POISON  | I high toxicity | 0 - 50 | taste to 1 tsp. | 0 - 200 |
| WARNING | II moderate toxicity | 50 - 500 | tsp to Tbsp | 200 - 2,000 |
| CAUTION | III low toxicity | 500 - 5,000 | 1 oz to 1 pt | 2,000 - 20,000 |
| CAUTION | IV relatively nontoxic | over 5,000 | more than 1 pt | over 20,000 |

6 Precautionary Statements

Precautionary statements are used to describe the hazards associated with a chemical. Always read and follow the instructions given in a precautionary statement. Three areas of hazard may include:

[6a] People and Domestic Animals - This section tells what hazards exist to humans or domestic animals through the route(s) of exposure and the precautions to be taken to avoid accident, injury or damage.

[6b] Environmental Hazards - This section indicates if the pesticide is toxic to nontarget organisms, such as honey bees, fish, birds, or other wildlife, and may contain information on how to avoid environmental contamination.

[6c] Physical and Chemical Hazards - This section explains special physical and chemical hazards, such as risks of explosion if the chemical is exposed to sparks or hazards from fumes in the case of a fire.

7 Additional Information

This statement must appear on those products that have the precautionary labeling which appears on side panels rather than all on the front panel.

8 Registration Numbers

The EPA assigns each pesticide a registration number. The phrase "EPA Registration No." or "EPA Reg. No." must precede the registration number. This number identifies both the registrant and the product. For example: EPA Reg. No. 62719-6; '62719' identifies DowElanco as the Registrant and '6' identifies the product as Tordon 22K Herbicide.

9 Establishment Numbers

A label must also have an EPA establishment number. The establishment number is a code which identifies the actual establishment that formulated the product and the location of the establishment site of manufacture or repackaging of a pesticide. Example: EPA Est. No. 464-MI-1. '464' identifies DowElanco as the establishment, 'MI' indicates the establishment is located in Michigan, and '1' tells the reader, it is the first formulating plant in that state operated by DowElanco.

10 Contents

All labels must list (by weight or liquid volume) the net contents of the product.

11 Manufacturer

Pesticide labels always contain the name and address of the manufacturer, registrant, person or firm registering the product. Use this address if you need to contact the manufacturer for any reason (if the registrant is other than the manufacturer, the label should indicate both parties).

Example: DowElanco Chemical Company, Indianapolis, IN 46268

12 Statement of Practical Treatment

The statement of practical treatment tells what to do in case of pesticide exposure. It describes what emergency first aid measures to take when the pesticide contacts skin, splashes into eyes or if dust or vapors have been inhaled. This statement may also include a *Note to Physician*s statement.

Example: Monitor 4 Spray

Note to Physicians: Methamidophos is a cholinesterase inhibitor. Measurement of blood cholinesterase activity may be useful in monitoring exposure. If signs of cholinesterase inhibition appear, atropine sulfate is antidotal. 2-PAM (Protopam) is also antidotal and may be used in conjunction with atropine, but should not be used alone.

13 Directions for Use

The directions for use list all the target pests that the pesticide has been registered to control, plus the crops, plant species, animals, or other sites where the pesticide may be used. The directions may also include special restrictions that must be observed, such as crops that may or may not be planted in the treatment area and restrictions on feeding crop residues to livestock or grazing livestock on treated plants. These instructions tell how to apply the pesticide, how much to use, where to use the material, when it should be applied, and also include the pre-harvest interval for all crops, when appropriate. The pre-harvest interval is the time, in days, required after application before an agricultural crop may be harvested. Always follow these directions. It is a violation to use pesticides in a manner inconsistent with the label.

EPA requires all pesticide labels with agricultural uses to have an [13a] **Agricultural Use Requirements** statement. This statement is to remind employers to comply with the Worker Protection Standards (WPS), Title 40 Code of Federal Regulations (CFR) Part 170, to reduce the risk of pesticide-related illness and to provide information on the safe handling of pesticides. The label requires employers to inform agricultural workers and/or pesticide handlers about the following:

- ◆ personal protective equipment (PPE),
- ◆ restricted-entry interval (REI), and
- ◆ notification to workers about pesticide applications.

14 Misuse Statement

The **misuse statement** must appear on all products and state, in general terms, that it is a violation of Federal Law to use the product in a manner inconsistent with the label.

15 Category of Applicator Statement

A statement restricting the use of a product to a particular category of applicator may appear on some products in *various locations* on the label. For example, Diazinon 4E Insecticide - Recommended for Commercial/Industrial Use Only. All Restricted Use Pesticides will indicate that use of that product is by certified applicators or their licensed operators.

Storage and Disposal Directions

Directions for proper storage and disposal of the pesticide and empty pesticide containers are another important part of the label. Some pesticides have special requirements. For example the Roundup label states the product should be stored where the temperature remains above 10° F to keep it from freezing. Improper storage may cause a pesticide to lose its effectiveness or may cause an explosion or fire. Pesticides must always be stored out of the reach of children and animals. Storage areas should be locked and posted.

Proper disposal of unused pesticides and pesticide containers is essential to reduce human and environmental hazards. Disposal of pesticides is governed by federal, state, and local regulations. Specific information may be obtained from the MDA, if it is not included on the pesticide label.

► Material Safety Data Sheets (MSDS)

Chemical manufacturers must also provide material safety data sheets (MSDS) through dealers and other chemical distributors. MSDS's convey health and safety information about the product that may not appear on the pesticide label. For most chemicals, the MSDS supplements and expands on information provided on the label.

Important information provided on MSDS's includes product identification, hazardous ingredient identification, physical property information (appearance, odor, solubility, volatility, etc.), fire and explosion hazard data, reactivity data (reactions with other products), health hazard data, directions for safe handling and use, physician statements, protective gear requirements, and disposal information. The health hazard data section may be especially helpful because it describes acute and chronic health effects as well as listing primary routes of exposure.

The Occupational Safety and Health Administration (OSHA) Hazard Communication Standard, also known as "Worker Right-to-Know," is intended to protect our nation's workers through dissemination of chemical safety information on labels, MSDS's, and training programs. This law requires that MSDS's be made available and accessible at all times to employees in their work area.

Figure 1 Front Label Panel

RESTRICTED USE PESTICIDE LABEL

Side or Back Label Panel

[1] RESTRICTED USE PESTICIDE
FOR RETAIL SALE TO AND APPLICATION ONLY BY
CERTIFIED APPLICATORS OR PERSONS UNDER THEIR
DIRECT SUPERVISION

**[2] PRODUCT
NAME**

%

[3a] ACTIVE INGREDIENT:
[3b] (Common Name)
[3c] (Chemical Name)
[3d] INERT INGREDIENT:
TOTAL %

[3e] THIS PRODUCT CONTAINS _____ LBS OF _____ PER GALLON

[4] KEEP OUT OF REACH OF CHILDREN

[5] DANGER - POISON



[6] PRECAUTIONARY STATEMENT

[6a] HAZARDS TO HUMANS
[6b] ENVIRONMENTAL HAZARDS
[6c] PHYSICAL OR CHEMICAL HAZARDS
[7] SEE SIDE PANEL FOR ADDITIONAL INFORMATION

[8] EPA REG. NO. _____ [11] MFG BY: _____
[9] EPA EST. NO. _____

[10] NET CONTENTS 5 GALLONS

[13] DIRECTIONS FOR USE

[13a] AGRICULTURAL USE REQUIREMENTS
Use this product only in accordance with its labeling and
with the Worker Protection Standard, 40 CFR part 170.
This Standard contains requirements for the protection of
agricultural workers on farms, forests, nurseries, and
greenhouses, and handlers of agricultural pesticides. It
also contains specific instructions and exemptions
pertaining to the statements on this label about personal
protective equipment (PPE) and restricted-entry interval
(REI).

REIs vary from 4 to 72 hours.
A list of PPE required for early entry to treated areas.

[12] STATEMENT OF PRACTICAL TREATMENT
IF SWALLOWED _____
IF INHALED _____
IF IN EYES _____
IF ON SKIN _____

[14] MISUSE STATEMENT _____
[15] CATEGORY OF APPLICATOR _____
[16] STORAGE AND DISPOSAL _____

Figure 2 Front Label Panel

GENERAL USE PESTICIDE LABEL

[1a] (General use pesticides do not have a restricted use statement.)

[2] PRODUCT NAME

[3a] ACTIVE INGREDIENT:

[3b] (Common Name)

[3c] (Chemical Name)

[3d] INERT INGREDIENT:
TOTAL

%

%
100%

[3e] THIS PRODUCT CONTAINS _____ LBS OF _____ PER GALLON

[4] KEEP OUT OF REACH OF CHILDREN

[5] CAUTION

[6] PRECAUTIONARY STATEMENT

[6a] HAZARDS TO HUMANS

[6b] ENVIRONMENTAL HAZARDS

[6c] PHYSICAL OR CHEMICAL HAZARDS

[7] SEE SIDE PANEL FOR ADDITIONAL INFORMATION

Side or Back Label Panel

[12] STATEMENT OF PRACTICAL TREATMENT

IF SWALLOWED _____

IF INHALED _____

IF IN EYES _____

IF ON SKIN _____

[13] DIRECTIONS FOR USE _____

[13a] AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It also contains specific instructions and exemptions pertaining to the statements on this label about personal protective equipment (PPE) and restricted-entry interval (REI).

REIs vary from 4 to 72 hours.
A list of PPE required for early entry to treated areas.

[14] MISUSE STATEMENT _____

[15] CATEGORY OF APPLICATOR _____

[16] STORAGE AND DISPOSAL _____

CHECKLIST TO ENSURE SAFE AND EFFECTIVE USE OF PESTICIDES

Read the *label* before purchasing a pesticide to determine:

- ✓ If this is the pesticide required for the job. Do not purchase or select a pesticide based on the color of the label. Labels of the same color and general make-up may contain different active ingredients or be intended for different purposes.
- ✓ Whether the material is too toxic or hazardous to be used safely on the target site.
- ✓ If the amount of active ingredient is in percent or pounds per gallon.
- ✓ If the formulation is suitable for the spray equipment to be used and where the chemical can be applied.

Read the *precautionary statements* to determine:

- ✓ What hazards exist to humans or domestic animals.
- ✓ What hazards the pesticide poses to the environment.
- ✓ What physical and/or chemical hazards the pesticide possesses.

Read the label before *mixing the product* to determine:

- ✓ What protective equipment is required.
- ✓ What the warnings, poisoning symptoms, and antidotes are.
- ✓ What can be mixed (compatibility) with the chemical and how to properly mix it.

Read the label *before applying* to determine:

- ✓ When to apply the chemical (proper timing). Many pesticides are most effective at a particular stage of the pest's life cycle.
- ✓ How to apply the chemical. For example, what is the rate of application?
- ✓ Any *use* restrictions, including special instructions. Some pesticide labels contain special instructions regarding protection of ground water and/or endangered species. Highly

leachable pesticides may be restricted in areas with high ground water tables and porous soils. Pesticides which can cause risk to endangered species may be restricted or forbidden in some areas. If applicable, county specific bulletins and maps outlining restricted areas will be available from pesticide dealers, county extension agents, and the MDA.

- ✓ Any special precautions on whether or not to use a surfactant. Example -- use will cause crop stress or reduce selectivity.
- ✓ If any crops are restricted (example: Harmony/Ally can be used on wheat and barley only).
- ✓ Often related products can't be used for the same pest on the same crops (examples: 2,4-D ester vs. amine, Ally vs. Glean, and Banvel vs Banvel II).

Read the label before *storing or disposing* of the pesticides and their containers to determine:

- ✓ Where and how to store the pesticide properly.
- ✓ How to decontaminate and dispose of containers.
- ✓ Where to dispose of any excess pesticide.

Remember that the uses of *alternative application equipment and tank mixes* not listed by labeling; *application at less* than labeling rates; and *application of pesticides to unnamed target pests* is allowed by 1978 amendments to FIFRA. The use under the above conditions warrants the following considerations:

- ✓ The responsibility for efficacy or effectiveness of the pesticide against unnamed target pests rests with the applicator.
- ✓ The manufacturer may not be liable for the efficacy of a product if used under the aforementioned amendments.

Warning Concerning Sources of Pesticide Information

Accepting information about pesticides from unreliable sources can create problems for yourself and others. Always refer to labels and labeling information for the most accurate information. One mistake can cost money, injury to humans or the environment or cause legal problems.

Guard against the following:

- Friends mean well, but often cannot remember the name of a product or may know very little about the problem or the product.
- Using unreliable sources other than licensed dealers, chemical sales representatives, and specialists who work in pest management, for recommending pesticides.
- Interested bystanders may offer suggestions that may not be correct.
- Old bulletins and circulars from state or federal sources should be disregarded if more current information is available.
- Sales catalogs may contain incomplete or out-of-date information. Doubtful recommendations should be checked against up-to-date information.
- Memories should never be trusted. Many pesticide chemical names sound alike.
- Trade names may not be consistent with the actual chemical ingredient.
- Recommendations from other states may or may not apply to Montana. Never accept recommendations on any pesticide without knowledge of the source and the validity of the source.
- Be very cautious about purchasing pesticides over the telephone. Always ask to see a label before buying and check with the MDA to be sure it is registered for use in Montana.

How to Choose a Pesticide

The following is a sample of the types of questions that should be asked when choosing the most effective pesticide:

- What is the crop (including crop stage and variety)?
- What is the pest (be specific - beetle, caterpillar, broadleaf weed, etc.)?
- What is the stage of development of the pest (2 leaf vs. rosette or larva vs. adult)?
- How serious is the problem (field wide, border infestation, etc.)?
- What are the climatic conditions (wet, hot, cold, dry)?
- How many acres need to be treated?
- Are you planning to graze the area to be treated?
- What crop will you be planting in this area next year?
- What is next to the area to be treated (sensitive crop, house, lake, stream)?
- When do you plan to harvest?
- What kind of a sprayer do you plan to use? Is it, or has it been recently calibrated?
- Do you need a license or permit that allows you to use restricted use pesticides or apply commercially?

Often several pesticide products are available for the control of a specific pest, but not all are appropriate for the given site or situation. When called upon to give a recommendation, it is the dealer's or applicator's responsibility to be aware of additional factors that influence choice of the correct pesticide product. Poor recommendations result in poor pest control, crop injury or off-target damage. You should be familiar with the limitations of all pesticides you sell or apply.

Obviously, not all of these questions would apply for all recommendations, but they provide a guideline of the types of things you need to know, so you can make a good pesticide choice.

CHAPTER V

PESTICIDE APPLICATION: FORMULATIONS AND EQUIPMENT

► **Pesticide Formulations**

Pesticide chemicals in their “raw” or unformulated state are usually not suitable for use in pest control because they are highly concentrated, may not mix well with water, and may be chemically unstable. For these reasons, manufacturers add substances to improve storage, handling, application effectiveness, and to make the chemical safer to use. The final product is known as a *pesticide formulation*. This formulation consists of:

- the pesticide active ingredient;
- the carrier, such as an organic solvent or mineral clay;
- surface-active ingredients, often including stickers and spreaders; and
- other ingredients such as stabilizers, dyes and chemicals that improve or enhance the action of the pesticide.

Liquid pesticides sometimes have antifreeze added for protection against freezing. Usually a formulation is mixed with water or oil for final application, but baits, granules, and dusts are ready for use without additional dilution. Some specialized pesticides, especially products designed for the homeowner, may be sold in ready-to-use formulations.

Formulation type is usually indicated by letters that follow or are a part of the brand name of the pesticide. For example, the “WP” represents a wettable powder and the “EC” indicates that the pesticide is an emulsifiable concentrate. These codes may also describe how the pesticide is intended to be used, what it is used for, or will describe some special characteristics of the formulation. See Table 5.1 for more pesticide formulation codes.

The amount of actual pesticide in a dry formulation is expressed as percent of active ingredient (a.i.). For instance, a 50-W wettable powder contains 50% by weight of actual pesticide. The amount of active ingredient in liquid formulations is represented by the pounds of active ingredient in 1 gallon of formulated pesticide. For example, in “Lorsban 4E” the “4” indicates that there are 4 pounds per gallon of the active ingredient *chloryprifos*.

It is often possible to select from two or more formulations of the same pesticide for control of a target pest. When this is possible, make your selection based on the type of control desired, safety, cost, and other factors. For example, emulsifiable formulations of insecticides usually provide a faster kill but have a shorter residual action, as compared with wettable powders. Whenever a choice is available, consider the safety to pesticide applicators, helpers, persons working or living in the area of application, pets, and livestock. Also, select a formulation that is compatible with available application equipment. Evaluate the habits and growth patterns of each pest, and be sure that the formulation is suitable for the life stage that needs to be controlled. Cost can also influence the formulation selection. Environmental concerns are of equal importance; choose a formulation that will cause the least harm to the environment. Drift, runoff, wind, and rainfall must be considered, along with soil type and characteristics of the surrounding area.

Table 5.1 Suffixes of Chemical Brand Names

| Suffixes Describing the Formulation | | | |
|---|-----------------------------|---------|------------------------------|
| D | Dust | P or PS | Pelleted |
| DF | Dry Flowable | S or SP | Soluble Powder |
| E or EC | Emulsifiable Concentrate | SG | Sand Granules |
| ES | Emulsifiable Solution | SL | Slurry |
| F or FL | Flowable | ULV | Ultra-Low-Volume Concentrate |
| G | Granular | W or WP | Wettable Powder |
| OL | Oil-Soluble Liquid | WDG | Water-Dispersible Granules |
| Suffixes Describing How a Pesticide is Used | | | |
| GS | For treatment of Grass Seed | RTU | Ready To Use |
| LSR | For Leaf Spot and Rust | TC | Termiticide Concentrate |
| PM | For Powdery Mildew | TGF | Turf Grass Fungicide |
| RP | For Range and Pasture | WK | To be used with Weed Killers |

Common Pesticide Formulations:

- ✓ **Emulsifiable concentrates (EC)** are petroleum-soluble pesticides formulated with emulsifying agents and other enhancers. Solvents will not mix with water, but emulsifiers enable the dissolved pesticide to form a suspension. When emulsifiable concentrates are added to water, a milky substance, known as an emulsion, is formed. Agitation is necessary during application to keep the emulsion uniform.
- ✓ **Invert Emulsions** are liquid formulations having small water droplets suspended in oil. Invert emulsion concentrates have the consistency of mayonnaise and are usually safer for handling and mixing than other liquid formulations. Invert emulsions aid in reducing drift and are primarily used for this purpose. Drift is often a problem with regular emulsions and other formulations because water droplets begin to evaporate before reaching the target surface.
- ✓ **Wettable powders (WP)** are formulations consisting of the pesticide combined with a finely ground dry carrier, usually mineral clay, along with other ingredients that enhance the ability of the powder to suspend in water. Wettable powders always require agitation during application to keep the mixture suspended. A high percentage of active ingredient in the formulation makes the wettable powder more hazardous and requires more care because of the potential of dust inhalation when handling and mixing.
- ✓ The active ingredient in **dry flowables (DF)** or **water-dispersible granules (WDG)** is incorporated with emulsifiers and other enhancers, similar to wettable powders. However, rather than being a powder, the pesticide formulation is formed into granules that must be mixed with water before use. Dry flowables require constant agitation during application. Water-dispersible granules pour cleanly from the container, giving them handling advantages over dispersible liquids and wettable powders.

✓ **Granule and Pellets (G) and (P):** *Granule and pellet* formulations have been impregnated into coarsely ground carriers such as clay or vermiculite and formed into small pellets ranging from 2-10 mm in size. These chemicals are used directly from the bag, may require special application equipment, and may require soil incorporation to be effective. Although granular formulations may be applied uniformly over crop fields, they are frequently used for spot treatments in many pest control applications.

✓ **Baits** consist of pesticides combined with food, an attractant, and/or a feeding stimulant. Baits attract target pests to a pesticide, eliminating the need for widespread pesticide application. Sometimes target pests carry baits back to their nestbound young. Baits are used indoors for control of rodents, ants, roaches, and flies. Outdoors they are used to control slugs, snails, insects, and vertebrates such as birds, rodents, and larger mammals. However, be aware of the dangers associated with baits which include their attractiveness to nontarget animals and to children.

✓ **Dust (D)** formulations consist of finely ground pesticide combined with an inert dry carrier. Dusts are effective where moisture from a liquid spray can cause damage to the crop, foliage, or sprayed surfaces. In addition to hazards of drift to nontreated areas, dusts present serious inhalation hazards to applicators. To prevent injury, wear respirators whenever using dust formulations.

✓ **Ultra Low Volume (ULV)** concentrates are highly concentrated pesticide solutions, usually between 80 - 100% active ingredient. The active ingredient is applied in its concentrated form. Evaporation is reduced because water is absent. ULV droplets are of greater density than those in water based sprays, thus increasing their rate of fall. Because less volume of formulation is applied per acre, more acreage can be treated before reloading.

✓ **Fumigants** can be either solid, liquid, or gas. Solids and liquids evaporate into a gas after or during application. Fumigants, which are gases at room temperature, are packaged under pressure in steel cylinders and are metered into the treatment area through valves and hoses. Fumigants present a serious inhalation hazard to applicators and other people in or near the treated area. Applicators often must wear supplied air breathing equipment and protective clothing.

✓ **Aerosols** combine the pesticide under pressure with a chemical propellant. There are two types of dispensers:

aerosol foggers - emit pesticides as a fine airborne mist or fog. Aerosol foggers are generally one-time, total release units, and contain a high percentage of pesticide. Residential, industrial, and institutional pest control operators frequently use aerosol applicators, since they require no mixing or special application equipment.

pressure spray applicators - produces a coarse spray of liquid or powder. Pressure spray applicators allow a pesticide film to be sprayed directly onto surfaces. This type of formulation may contain a lower percentage of pesticide combined with a petroleum oil carrier and is often used in adult mosquito control.

✓ **Microencapsulated Formulations** are liquid or dry pesticide particles that may be surrounded by a plastic coating. Microencapsulated pesticides must be mixed with water and are sprayed in the same manner as other sprayable formulations. After spraying, the active ingredient is released gradually as the plastic coating breaks down. There are several advantages to this type of formulation:

- ➡ highly toxic materials are safer for applicators to mix and apply;
- ➡ delayed or slow release of the active ingredient prolongs its effectiveness;
- ➡ the pesticide volatilizes more slowly, so less will drift away from the application site; and
- ➡ these formulations are not as phytotoxic to sensitive plants.

In residential, industrial, and institutional applications, microencapsulated formulations offer the advantages of reduced odor, release of small quantities of pesticide over a long period of time, and greater safety. Microcapsules have less dermal hazard than ordinary formulations. There is a special hazard to bees because microcapsules are about the same size as pollen grains; bees may carry them back to their hives before the plastic coating breaks down, resulting in poisoning of adults and brood once the pesticide is finally released.

✓ **Water-Soluble Packets** are used to reduce the mixing and handling hazards of some highly toxic pesticides. Preweighed amounts of wettable powder or soluble powder formulations are packaged in water-soluble plastic bags. When the bags are dropped into a filled spray tank, they dissolve and release their contents to mix with the water. There are no risks of inhaling or contacting the undiluted pesticide during mixing as long as the packets are not opened. Once mixed with water, pesticides packaged in water-soluble packets are no safer than other mixtures.

The following table can be used as a quick reference when comparing formulations:

| Formulation | Mixing/ Loading Hazards | Phytotoxicity | Effect on Application Equipment | Agitation Required | Visible Residues | Compatible with other Formulations |
|--------------------|-------------------------------|---------------|---|-----------------------|---------------------|--|
| WP | Dust inhalation | Safe | Abrasive | Yes | Yes | Highly |
| DF / WDG | Safe | Safe | Abrasive | Yes | Yes | Good |
| SP | Dust inhalation | Usually safe | Non-abrasive | No | Some | Fair |
| EC | Spills / Splashes | Maybe | May affect rubber pump parts | Yes | No | Fair |
| Flowables | Spills / Splashes | Maybe | abrasive; may affect rubber pump parts | Yes | Yes | Fair |
| Solutions | Spills / Splashes | Safe | Non-abrasive | No | No | Fair |
| Dusts | Severe dust inhalation | Safe | --- | Yes | Yes | --- |
| Granules / Pellets | Safe | Safe | --- | No | No | --- |
| Microencapsulated | Spills / Splashes | Safe | --- | Yes | --- | Fair |

♦ Spray Additives

The mode of action of pesticides may be improved by the addition of accessory materials and adjuvants. Accessory materials include diluents, carriers, solvents, and adjuvants.

Carriers are added to concentrates and give the formulation “body” and “surface” adequate for application. Carriers are often inert ingredients such as water in flowables or talc in dusts.

Diluents are liquids added to reduce the concentration to the appropriate application rate.

Solvents are used to dissolve a formulation into a carrier or diluent; they are usually utilized when the formulations are solid or viscous. Diluents and carriers may also act as solvents.

Adjuvants or spray additives are often used to enhance pesticidal performance or handling. These substances may increase spreading properties, assist emulsification, promote penetration of plant parts, reduce interfacial tensions, and perform other related functions. Adjuvants are either incorporated into the pesticide formulation at the time of manufacture or added by the applicator under certain restricted conditions. The addition of proper adjuvants can result in a more effective and economical pesticide. Adjuvants include surfactants, anti-foaming agents, compatibility agents, crop oils, crop oil concentrates, and drift control agents.

Surfactants (surface-active agents) enhance spray coverage by reducing the surface tension of spray droplets. Surfactants are used for getting good coverage on waxy or hairy surfaces, such as leaves of many plants or the outer covering of insects and mites. They also help to get spray into small cracks or openings. Surfactants are classified as *ionic and nonionic*, depending on their disassociation in water. Nonionic agents have no particle charge, while ionic agents have either a positive or negative charge.

Nonionic surfactants are classed as non-electrolyte and are usually chemically inactive in the presence of salts. They can be mixed with most pesticides and still remain chemically inactive.

Ionic surfactants ionize in an aqueous medium. These agents can be used to unite oil or water soluble properties of a molecule and allow alignment in water to reduce water surface tension.

A surfactant is any material that affects the surface properties of spray solutions and includes emulsifiers, dispersing agents, detergents, and stickers.

*An *emulsifier* is a material used to disperse one liquid in another. An emulsion is one liquid dispersed in another, each maintaining its original identity.

**Dispersing agents* reduce cohesion between particles. They are materials used to disperse the particles of a solid in a liquid. Some dispersing agents also act as wetting agents, but others have little or no effect on surface tension. Some wetting agents and dispersing agents are not compatible and interfere with each other if used together.

**Detergents* are used to remove dirt or grime. They are usually wetting agents and surface active. Many common detergents have been used with pesticides as wetting agents and emulsifiers. Anti-foaming agents can be used to reduce foaming in a sprayer system so pumps and nozzles can operate properly.

*A *sticker* is designed to hold the active ingredient on the sprayed surface.

*A *penetration agent* is any substance that assists plant absorption of a pesticide. Such substances may dissolve the waxy cuticle or fatty portion of the cell wall or membrane of the plant to allow more rapid penetration.

**Anticaking agents* are used to prevent solid pesticide formulations from forming aggregates.

Compatibility agents aid suspension of pesticides when they are combined in tank mixes with other pesticides or fertilizers. They are used frequently when a liquid fertilizer is the carrier solution.

Crop oil and crop oil concentrates are non-phytotoxic light oils that also contain surfactants to allow mixing with water. They are added to water solutions to enhance pesticide foliar activity.

Drift control agents reduce the fine particles in a spray pattern that are primarily responsible for pesticide drift and nontarget injury.

All adjuvants should be used in accordance with label directions and chosen only from those proven effective for pesticide applications. Refer to the manufacturer's recommendations and pesticide label recommendations.

► Viscosity Modifiers

Viscosity modifiers are agents which simply increase the viscosity of water or oil carrier. They will create a particulate foam, thixotropic nature (gel to liquid upon shaking), or produce a two-phase mix of oil and water called *invert emulsion*. These additives increase droplet size, and therefore, decrease drift.

A *particulating agent* is a water swellable polymer that absorbs water but does not dissolve. Particulating agents are probably the most effective drift control agents for water soluble herbicides.

Thixotropic wax products act differently than plain thickening agents. When they are added to water, thickening occurs, but when dispersed under pressure or shear, the material thins and thickens again as the spray leaves the nozzles.

An *invert emulsion* is formed when an oil phase in the water-oil mixture becomes continuous and the water is dispersed in cells. Invert emulsions reduce evaporation because the oil film

surrounds the water. Various inverts can reduce drift by as much as 60-99 percent in comparison with normal water sprays. Invert emulsions can be mixed in the tank before spraying or mixed in the line or pump as they are being sprayed (bi-fluid system). The viscosity of invert emulsions is increased by using more inverting agent, decreasing the oil, and increasing agitation. Oil to water phase ratios may range from 1 part oil to 2 parts water to as high as 1:15.

Individuals interested in viscosity modifiers should consult with technical representatives of chemical companies, Extension Service Personnel, or the Montana Department of Agriculture (MDA).

► **Compatibility of Pesticides**

Application of one pesticide at a time has been the common agricultural practice. Today, because of the high cost of application, pesticide applicators are mixing pesticides in an attempt to control several pests with a single application.

Pesticides are compatible when two or more can be mixed together without any adverse changes in action or structure. Some pesticides, however, are incompatible because adverse changes occur between the active ingredients or formulations. Several reasons for incompatibility are given below:

- **Physical incompatibility** is difficult to evaluate and is often caused by the additives rather than the pesticides being incompatible. The results of physical compatibilities are varied. A common one is the formation of precipitates in the mixture that can plug screens and nozzles. Another occurs when the activity of an emulsifier is stopped. Mixtures may then separate or form large droplets within the tank.
- **Chemical incompatibility** occurs when chemical reactions occur that destroy the effectiveness of one or more pesticides. For example, fungicides or adjuvants that are strongly alkaline may decompose synthetic organic insecticides and change their activity. Precipitates may occur that will plug screens and spray nozzles. Formulations may be altered so that they no longer contact or adhere to the target. Reactions may occur which cause the formulation to be toxic to plants or phytotoxic. Chemical incompatibilities cannot always be recognized in the spray tank.
- **Timing incompatibility** - Pesticides must be applied at the most susceptible development stage of the pest for greatest effectiveness. When spraying a mixture of two or more chemicals, it may be difficult to time the application to the most susceptible stage of the various pests.
- **Water incompatibility** - Water is the most common carrier for pesticides. Water hardness (high amounts of calcium) may alter the formulation of a pesticide making application difficult or less effective. Generally, waters that are "soft" should be utilized as carriers. Applicators should determine the hardness of water in their area prior to mixing one or more pesticides. Water may be softened chemically, thus preventing problems in mixing pesticides.

Points to Consider When Mixing Chemicals

- ◆ The compatibility of the various chemicals must be known before the materials are combined.
- ◆ As a general rule, do not mix herbicides with insecticides.
- ◆ Follow all label directions carefully. The use of tank mixes not specifically stated on the label is discouraged by most manufacturers.
- ◆ Combinations containing lime or having a high alkalinity are harmful to synthetic organic chemicals. Most organophosphates and carbamates are subject to alkaline decomposition.
- ◆ The use of oils and petroleum solvents in combination with organic chemicals may increase phytotoxicity.
- ◆ Most dinitro miticides may become phytotoxic if mixed with oil.
- ◆ Organophosphates combined with dinitros may cause burning of foliage.
- ◆ Consult all available sources before utilizing combinations.

Compatibilities of various chemicals can be checked by referring to a *compatibility chart* in the Farm Chemicals Handbook. Some chemical companies also print compatibility charts.

Caution is imperative to any applicator wishing to check unknown compatibilities. Chemical or phytotoxic compatibilities cannot be observed. Keeping the above points in mind, physical compatibilities can be checked by mixing small amounts of chemicals in jars. These mixtures should be observed initially and after one hour for any adverse changes such as settling, precipitates, gumminess, separation, etc.

Pesticide labels will often list compatible and incompatible chemicals. If not, it is permissible by the FIFRA to mix pesticides or pesticides and fertilizers. *This should be done with caution.* Contact the MDA Pesticide Specialist in your area for assistance.

► Types of Ground Equipment

The five basic classes of ground application equipment include hydraulic sprayers, air sprayers, foggers and aerosol generators, power dusters, and hand held equipment.

✓ **Hydraulic sprayers** deliver the pesticide under pressure by a pump to one or more nozzles. Hydraulic sprayers are of 4 basic types:

Multiple-purpose sprayers provide versatility for a variety of farm problems. Spray pressure is adjustable and can provide, for example, 40 pounds for weeds or 400 pounds or more for spraying fruit trees. Tank size ranges from 50 to 200 gallons. Sprayers are skid or wheel mounted and powered by auxiliary engines or a PTO. Spray is dispensed through a hand gun or field boom.

Small general use sprayers are useful for small spraying jobs that are too large for hand equipment. They are useful in greenhouses, large gardens, and golf courses. Tank capacities vary up to 25 gallons. Power is from a $\frac{1}{2}$ to 2 horsepower engine that

provides a wide range of pressures (50-500) psi. Spray is dispensed through a hand gun or short boom. Sprayers are usually mounted on a hand-operated cart; some can be attached to a garden tractor.

Low-pressure, low-volume sprayers are commonly used in Montana crops. They can be mounted directly on equipment or are equipped with wheels. Sprayer tanks hold up to 250 gallons. Power is usually from the tractor PTO but may be supplied by an auxiliary engine. Operating pressure is up to 100 pounds and spray is dispensed through a field boom. Some sprayers, the Spray Coupe for example, are self-propelled.

High-pressure, high-volume sprayers are used by fruit growers and truck farmers in order to obtain good penetration and coverage in tall growing trees and dense crop growths. These sprayers are essentially the same as multiple-purpose sprayers except that larger engines provide up to 1000 pounds of pressure. Tank sizes are also larger and range up to 600 gallons.

✓ **Air sprayers** (also known as ultra-low volume, concentrated blower, air-blast, and air-mist sprayers) are used for spraying orchards, large shade trees, and field crops. Pesticides are applied in concentrated form using relatively small volumes of water in contrast to hydraulic sprayers. Labor involved in loading is saved and pesticide runoff is reduced. A low-volume pump delivers the liquid spray under low pressure to the fan where it is discharged into an air stream in small droplets by a group of nozzles or shear plates. Pump pressures range from 50 to 400 p.s.i. and fans deliver from 5000 to 25,000 c.f.m. or air velocities of 100 to 150 m.p.h.

✓ **Foggers or Aerosol Generators** are designed primarily for control of mosquitoes and flies in large buildings, parks, resorts, or communities. These machines disperse fine particles of pesticides into air, as fogs or mists, where they remain for a considerable time period. Fogs and aerosols are produced by either thermal (heat) or mechanical methods or a combination of both. Aerosol equipment is not practical for most agricultural pesticide applications (especially herbicides) because of their tendency to create drift problems.

Air currents assist in moving the pesticide to the target area, taking advantage of the principle of air inversions. Applications are usually made at night when wind, temperatures and humidity conditions are more likely to be optimal.

✓ **Power dusters** are powered by engine or PTOs. Like air blast sprayers, dusters also utilize air streams from a centrifugal fan to carry the pesticide to the target area. They may have single or multiple outlets. Dusters may be impractical for application of some pesticides, especially herbicides, because of the drift hazard.

✓ **Hand application equipment** is designed primarily for application of pesticides in small areas like homes, gardens, businesses, or yards. This type of equipment includes hand pump atomizers, aerosol dispensers, compressed air sprayers, knapsack sprayers and dusters.

The hand pump atomizer uses a hand operated pump to force an air stream over the tip of a siphon tube. Pesticide is sucked from the tube and atomized in the air stream. The intermittent type sprayer produces a spray only on the forward motion of the pump. The continuous sprayer delivers a continuous spray because pressure is produced in the tank. These sprayers are commonly used to control flying insects in the home. They have nearly been replaced now by aerosol dispensers.

Aerosol dispensers or "bug bombs" are probably the most common type of applicator. The pesticide and a propellant are forced, under pressure, through an atomizing nozzle. Many household pest sprays are dispensed as aerosol bug bombs.

Compressed air sprayers are designed to hold 1 to 3 gallons in the tank. A hand pump is used to pressurize the tank and to deliver the pesticide, under pressure, to the nozzle. Spray patterns and droplet size can be regulated by nozzle type. Solutions, emulsions, or suspensions of pesticides can be utilized at pressures which range from 30 to 50 psi. The use of CO₂ cylinders in place of the hand pump may be utilized to achieve correct pressure.

Knapsack hand sprayers are carried on the back and usually have a capacity of 5 gallons. A hand operated piston or diaphragm pump provides the pressure (30 to 100 psi) to expel the pesticide.

Duster hand sprayers range from small self-contained units to those mounted in wheelbarrows. Air velocity for dispensing the dust is created by a plunger, hand crank, or belt attached to a fan or blower.

◆ Accessory Equipment

Nozzle Types and Selection

Proper selection of nozzle type and size is an important part of pesticide application. The nozzle determines the amount of spray applied to a given area, the uniformity of the applied spray, the coverage obtained on sprayed surfaces and the amount of drift that may occur. The choice of nozzle type is determined by field conditions and a knowledge of the characteristics of the different types of nozzles. Selection of nozzle type is dependent on the type of application being conducted. Most pesticide applications will use one of the following nozzle types:

Regular Flat-Fan nozzles are recommended for most broadcast spraying of herbicides and some insecticides where foliage penetration is not required. When applying herbicides with flat-fan nozzles, the pressure should be between 15 and 30 pounds per square inch (psi) and never over 40 psi. Flat-fan nozzles are normally spaced 20 inches apart, with boom heights varying from 17 to 23 inches. Nozzles produce a fan shaped spray pattern with tapered ends and are available in several spray angles. The tapered ends of the pattern have lower volumes which require overlapping of adjacent patterns for uniform coverage. The spray patterns should overlap about 30 percent and the nozzles should be rotated approximately 12 to 15 degrees off the boom line to prevent the patterns from infringing on each other and destroying the uniformity of coverage.

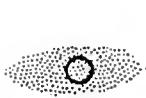
Flooding Flat-Fan nozzles are used for applying herbicides and mixtures of herbicides and fertilizers. This nozzle produces a wide angle flat-fan pattern that is generally not as uniform as the regular flat-fan tip. Spray is concentrated in the center of the pattern, followed by a small interval of less spray and then another heavy concentration on the outer edges. Therefore, the best distribution is achieved when the nozzle is mounted at a height to obtain at least double coverage, or 100 percent overlap. To get the right overlap, the sprayed area from one nozzle must be twice the spacing of the nozzle from another nozzle on the boom. For example: If flood nozzles are placed on 40 inch centers, the sprayed area on the ground from one nozzle must be 80 inches to get 100 percent overlap. Because of the wide spray angle, these nozzles can be widely spaced on the boom and carried close to the ground to reduce drift. The best drift reduction with flood nozzles is achieved when they are operated within a pressure range of 8 to 25 psi with the nozzles angled 10 to 15 degrees in the direction of travel. Pressure changes affect the width of the spray pattern in this nozzle more so than in the regular flat-fan nozzle.

Even Flat-Fan nozzles apply an even coverage across the entire width of the spray pattern. They should be used only for banding pesticides over the row and be operated between 15 and 30 psi. Width is determined by adjusting nozzle height. The wider the nozzle spray angle, the lower the height needed to spray a desired band width.

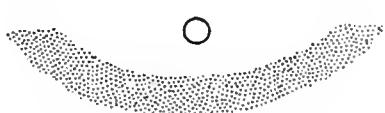
Hollow Cone nozzles are used primarily when plant foliage penetration is essential, such as orchard applications, for effective insect and disease control where drift is not a major concern. At pressures of 40 to 80 psi, these nozzles produce small drops that penetrate plant canopies and cover the undersides of leaves more effectively than other nozzles. If canopy penetration is not required, the pressure should be limited to 40 psi or less. The most commonly used hollow cone nozzle is the two-piece disc-core hollow cone spray tip. The core gives the fluid a swirling motion as it is metered through the disc orifice, resulting in a circular hollow cone spray pattern. For adequate coverage of a row crop, one to five nozzles can be used per row, depending on plant size.

Whirl Chamber Hollow Cone nozzles have a whirl chamber above the conical outlet. These nozzles produce a hollow cone pattern with fan angles up to 130 degrees and are used mainly on herbicide incorporation kits. The recommended pressure range is 5 to 20 psi.

Raindrop® Hollow Cone nozzles are designed to produce very large drops in a hollow cone pattern at pressures of 20 to 60 psi. When used for broadcast application, the nozzle should be rotated 30 to 45 degrees from horizontal to obtain uniform distribution.



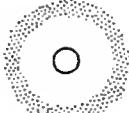
Regular flat-fan nozzle pattern



Flooding flat-fan nozzle pattern



Even flat-fan nozzle pattern



Hollow cone nozzle pattern

Nozzle Materials

Nozzle tips are available in a variety of materials. Brass tips are the most common and are the most economical for limited use. However, they wear rapidly when used to apply abrasive materials, such as wettable powders, and are corroded by some liquid fertilizers. Plastic (nylon) tips are resistant to corrosion and abrasion, but are subject to swelling when exposed to some solvents. The best tips are stainless steel, hardened stainless steel, and ceramic. Ceramic is the best and most wear resistant of all tip materials, but also the most expensive. Stainless steel tips have excellent wear resistance with either corrosive or abrasive materials.

Nozzle Numbering and Coding

Unfortunately, there is not a uniform system of nozzle numbering. Each manufacturer will indicate flow rate, spray angle, and other information by number and letter codes. Flow rates are measured in gallons per minute (GPM) at a standard pressure of 40 psi using water. For further reference, nozzle manufacturers' catalogs and bulletins provide an excellent source of information.

Handgun Discs

Handgun equipment generally have discs rather than nozzle tips. Discs have a uniform system of numbering. The spray or cap number represents the diameter of the orifice in increments of 1/64 of an inch. For example, No. 3 disc has an orifice 3/64 inch in diameter. Larger orifices deliver coarser droplets at higher rates. To determine the proper disc size for your operation, consult manufacturers' charts.

Nozzle Flow Rate or Capacity

The flow rate of a nozzle is increased by larger metering passages and exit orifices. Flow rate is also affected in varying degrees by pressure, liquid density, and liquid viscosity.

- Flow rate varies in proportion to the square root of the pressure. As pressure increases, so does pesticide flow rate. For example, to double the flow output, pressure would have to be quadrupled.
- As the pesticide density becomes greater, flow rate is reduced.
- Effects of viscosity on flow rate are complex, but generally, flow rate decreases as liquids become more viscous.

Many applicators may not be interested in the above factors but they should be aware of their effects on flow rate. The above effects on nozzle flow rates illustrate the importance of calibrating when changing nozzle size, pressure, or spray mixture.

Spray Angle and Pattern

Pressure and liquid viscosity influence spray angle and pattern.

Pressure - A minimum pressure is required to develop a proper spray pattern, usually 10 to 15 psi. Lower pressures tend to produce a distorted spray pattern. When pressure is too great, the nozzle will begin to atomize the spray and the pattern will be changed. Applicators can make the mistake of operating at excessive pressures in order to make the spray reach further. Actually the opposite effect may occur as the spray atomizes, the pattern changes, and drift may occur. A nozzle with a larger orifice should be used.

Liquid Viscosity - Viscosity is the only liquid property that has a significant effect on spray patterns. An increase in viscosity produces a narrower pattern and smaller spray angle. At very high viscosities, the spray may become a straight stream.

Atomization & Droplet Size

The range of droplet size is affected primarily by the nozzle orifice size and pressure. Each nozzle produces a variety of droplet sizes, the majority centered around one size. Droplets are measured in micrometers or microns where 25,400 micrometers equal one inch. Volume Mean Diameter (VMD) is also used as a measure of droplet size. VMD is that droplet diameter whose volume, if multiplied by the number of droplets, will equal the total volume of the sample. To give an idea of droplet sizes, the following chart is included.

| Category | Droplet Size (micrometers) |
|--------------|----------------------------|
| Fog | 0.1 - 50 |
| Aerosol | 1.0 - 50 |
| Mist | 50 - 100 |
| Fine Spray | 100 - 400 |
| Coarse Spray | Greater than 400 |

Droplet size is influenced by:

Nozzle rating and design is the primary factor influencing droplet size. As nozzle capacity and metering passages increase in size, the average droplet generally becomes larger. Spray angle ratings also affect droplet size. Wider spray angles are associated with finer droplets.

Pressure - As pressure increases, more droplets of a smaller size tend to be produced. A limit is eventually reached where increasing pressure has little effect in reducing droplet size.

Liquid Viscosity - As viscosity of a fluid increases, droplets become coarser. Increases in pressure will counteract the effects of viscosity.

Surface tension - Liquids with a higher surface tension are more difficult to atomize. The effect of surface tension is generally minor compared to viscosity.

Pumps

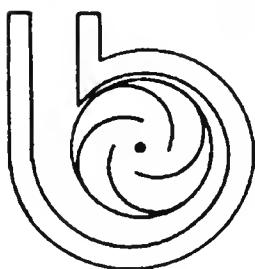
The sprayer pump is the heart of the system. Pumps vary in capacity, operating speed and pressure, and resistance to corrosion and wear. Capacity, which is affected by speed and pressure, should be large enough for high application rates. Pumps should provide for agitation if the sprayer does not have a mechanical agitator. Manufacturer's performance tables can assist you in selecting the proper pump. Some of the commonly used pumps are:

Centrifugal pumps commonly operate from a PTO and must be operated at high speed (3000 to 6000 rpm) to obtain adequate capacity. High output occurs at normal operating pressures (30-90 psi). They are not self-priming and must be located below the fluid level if a priming system is not used. They are resistant to wear and can pump wettable powders or other abrasives. In operation, liquid enters at the center of a rotating impeller with vanes molded in a spiral configuration. Liquid is forced along the vanes by centrifugal force and out a discharge hose.

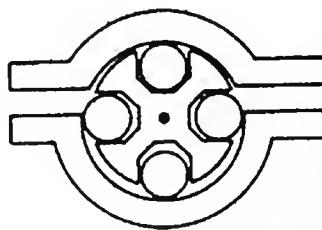
Turbine pumps exhibit the same advantages and disadvantages as centrifugal pumps. The primary differences are closer tolerances and additional fins. The optimum operating speed is 1000 rpm and can be operated directly from a 1000 rpm PTO shaft. A step-up drive is necessary for a 540 rpm PTO shaft. The impeller, nylon or cast iron, is a construction of many closely aligned turbine blades. The housing constricts around the blades at the exit port which forces the liquid from the pump.

Roller pumps are inexpensive, short-life pumps useful in a variety of situations. Operating pressure varies from 30 to 200 psi and outputs can reach up to 50 GPM. Higher pressures and operating speeds decrease pump life. These pumps are suitable for wettable powders but their abrasive nature shortens the pump life. The number of rollers varies from 4 to 8 depending on pump capacity. They are constructed of nylon, rubber, teflon or polypropylene plastic. In operation, a slotted rotor holds cylinder shaped rollers in an eccentric housing. As the rotor spins, the rollers are held against the housing by centrifugal force. Fluid is drawn into the entry port and held in the spaces between the rollers and the housing. At the exit port, the smaller space between the rotor and housing forces liquid into the exit port.

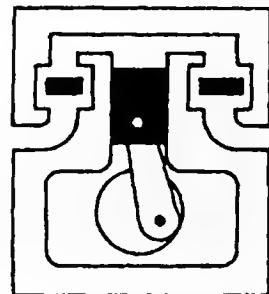
Piston pumps - Piston pumps are designed to operate at high pressures, although they may also be operated at low pressure. For most agricultural uses, 500 to 600 psi is normal, although some pumps may produce up to 1000 psi. Output is nearly proportional to pump speed which, depending on the pump design, may vary from 300 to 1800 rpm. Output from piston pumps is low, varying from maximums of 3 GPM to 25 GPM, depending on size, number of pistons, and operating speed. When spraying with pressures of 100 psi or more, a piston pump will provide the best long-term reliability. Most high pressure sprayers designed for such uses as ornamental tree spraying, livestock spraying or washing equipment are equipped with piston pumps. Piston pumps are expensive but well constructed and a long service life can be expected. They stand up to abrasive materials and worn parts can be replaced. Piston pumps are driven by a PTO or auxiliary engine. An eccentric camshaft moves the piston, fluid enters and is forced from one way valves in the piston housing. To smooth the pulsating discharge of liquid, a surge tank or pulsation damper is required.



Centrifugal pump



Roller pump



Piston pump

The following three pumps see little current use with agricultural sprayers:

➤ Gear pumps - These pumps incur a high wear rate, cannot be reconditioned, and must be discarded after they are worn.

➤ Diaphragm pumps - The pumping action in a diaphragm pump is produced by the movement of a flexible diaphragm. Liquid is drawn into one chamber on the downstroke and forced out of another on the upstroke. The diaphragm is resistant to wear by abrasives but may be attacked by certain chemicals.

➤ Flexible Impeller pumps - These pumps have a series of rubber vanes attached to a rotating hub. The pump housing squeezes the hub as the rotor turns, forcing the liquid from the exit port. Since the paddles will not return to the extended position if the pressure is too high, a pressure relief valve is not needed. They are inexpensive and the rotors are easily replaced. They are not suitable for abrasives but work well as low pressure transfer pumps.

Pressure Regulators

➤ Pressure Relief Valves maintain a constant pressure to the nozzles despite variations in engine speed. This spring loaded valve allows excess fluid to be bypassed into the tank and, when the boom is shut off, the entire pump output is routed to the tank. These valves are used with roller and piston pumps.

➤ Unloader Valves are recommended for high pressure situations as with piston pumps. When pressure becomes greater than the pressure setting, excess fluid is rerouted to the tank. Each time the nozzles are shut off, the unloader valve opens and routes the pesticide to the tank. Line pressure between the unloader valve and the nozzle(s) remains at operating pressure, allowing immediate use when spraying is resumed. The pressure of the liquid flowing through the unloader valve back to the tank is very low, saving fuel and pump wear. Some unloader valves, when properly adjusted, can serve as a partial relief by-pass valve.

➤ Throttling Valves (manually controlled) distribute and/or restrict the excess pump output. By opening or closing the throttling valve(s) in a spray system, pressure is decreased or increased. Throttling valves are used with centrifugal and turbine pumps.

Strainers and Screens

Screens and strainers remove foreign materials that might clog nozzles, wear pumps, or interfere with valves. Screens mesh size refers to the number of openings per linear inch. The higher the mesh size number, the finer the screen.

➤ Tank Screens are coarse screens that remove lumps of unmixed material and other large foreign materials when the tank is filled.

➤ Line Strainers are generally placed between the tank and the pump. They are an intermediate size, 10-80 mesh, and are necessary to prevent rust, scale, sand, or other small particles from entering and damaging the pump.

➤ Nozzle Screens fit inside the nozzle body and provide final screening of the liquid to protect the nozzle tips from plugging. Screens are commonly made of stainless steel or brass and have a mesh size smaller than the nozzle aperture. When spraying wettable powders, slotted strainers are recommended to prevent the buildup of suspended solids.

Clogged screens will cause erratic spray patterns, improper metering and delivery, or complete liquid blockage. Screens and strainers must be cleaned often using a soft brush or compressed air.

CAUTION: Do not blow into screens or nozzles to clean. You will get pesticide into your mouth, nose, eyes and on your face. These areas are highly susceptible to pesticide absorption.

Nozzle Check Valves

When boom control valves or the spray pump are stopped, the liquid remaining in the boom or hose lines will continue to drip from the nozzle and may cause crop damage. This undesirable dripping of spray material can be avoided by the use of nozzle check valves. When the line pressure drops below a certain low pressure, the valve automatically shuts off all flow. The boom remains full, pressurized, and ready for immediate resumption of spraying.

Agitators

Many pesticide products, particularly wettable powders and emulsions, require agitation to assure continuous mixing of the pesticide formulation. Agitation can be accomplished by manual, mechanical, or hydraulic methods.

➤ Manual Agitation by means of continuous shaking is sufficient for small hand held sprayers but impractical for large equipment.

➤ Mechanical Agitation is provided by a series of propellers or paddles mounted on a shaft near the bottom of the tank. Rotation speed is slow (100 to 200 rpm) because excessive agitator speed can cause foaming in some spray mixtures.

➤ Hydraulic Agitation is provided by returning a portion of the pump output to the tank. One method discharges the by-pass spray mixture through holes in a pipe located at the bottom of the tank. A second method uses agitator nozzles. By-pass liquid flows through the nozzles, drawing additional fluid into the moving stream through openings in the side of the nozzle. The volume of liquid for agitation can be increased 2 - 3 times by this method.

Some sprayers have a by-pass or overflow hose returning to the tank from which the spray liquid enters as an unrestricted straight stream. Although this provides circulation and mixing of the tank's spray mixture, it is generally not sufficient to maintain an adequate suspension of the pesticide product.

Pressure Gauges

Pressure gauges should be periodically checked for accuracy and should register within the range of pressures commonly used. Properly operating pressure gauges help insure proper application rates, keep drift to a minimum, and reduce equipment wear caused by unnecessarily high pressures. It is common for pressure to be lower at the nozzles than the registered gauge pressure. Pesticides moving through hoses, valves, couplings, and screens encounter resistance and thus pressure is lowered. To reduce pressure loss, hoses should be kept as short and as large in diameter as possible. Fittings should be kept to a minimum. Lines, nozzles, and screens should be cleaned often.

Sprayer Tanks

Sprayer tanks should have a large opening at the top that is splash proof and equipped with a coarse screen. The cover should be vented and sealed against dust. A drain plug should be located in the tank bottom. Corners should be round to facilitate agitation and cleaning.

Construction materials vary in durability and ability to withstand corrosion. The following are some common materials:

- *Galvanized Steel Tanks* give reasonable service if properly cared for but may eventually corrode. They are suitable for most pesticides but corrosive fertilizers and pesticides should be avoided. An epoxy lining will protect steel tanks from corrosion but is not effective against hydrocarbons, such as Lasso, or volatile chemicals under pressure.
- *Polyethylene Tanks* are lightweight and resistant to corrosive chemicals except for ammonium phosphate solutions and some liquid fertilizers. Polyethylene tanks must be replaced if cracked, broken or punctured. Polyethylene breaks down under ultra-violet light and should be kept covered when not in use.
- *Aluminum Tanks* resist corrosion by most chemicals. They should not be used with solutions containing phosphoric acid.
- *Fiberglass Tanks* are widely used on agricultural sprayers and are resistant to most chemicals but may be affected by some solvents. Fiberglass is a lightweight but durable material that can be repaired if cracked or broken.
- *Stainless Steel* is the highest quality material for spray tanks. It is strong, durable and resistant to corrosion by any pesticide or fertilizer. It is recommended for equipment with a high annual use.

The capacity of the tank will depend upon the size of fields to be sprayed, application rate, boom size, and soil conditions. Excessively large tanks require expensive supports and may compact soil or leave ruts.

► **Maintenance of Ground Equipment**

Care and maintenance of equipment will give the best results for your applications and help insure the safe use of pesticides. Improperly maintained sprayers can result in:

- ✓ Costly repairs
- ✓ Improper application rates
- ✓ Pesticide spills and other pesticide accidents
- ✓ Down time

Most dealers provide information and manuals for the care of their equipment, but the following information gives a brief summary on equipment care.

Inspection and Filling

Before use, examine the sprayer carefully for worn parts. Are the hoses cracked and leaking? Examine the suction hose carefully; any leaks will seriously interfere with the pump operation. Examine the boom struts carefully and adjust the boom to the proper height. Clean all components carefully and pay attention to screens, filters, hoses, and nozzles. Any dirt in these parts will interfere with application rates. Mix chemicals using only clean water. Dirt will plug screens and damage the pump. Water from a ditch or reservoir should be strained.

Cleaning the Sprayer

Rinsing the sprayer after use will reduce corrosion and prevent contamination of the next spray and accumulations on sprayer parts. Several rinsing solutions can be used depending on the carrier:

- ✓ Water and ammonia
- ✓ Water and soap or detergent
- ✓ Solvents

Choose cleaning areas with care so that pesticides are not rinsed onto lawns, children's play areas, or well head areas. Rinse your tanks in areas where humans, animals, or crops will not be exposed. Spray equipment should be cleaned according to the pesticide label and/or the manufacture's guidelines. However, the following is a suggested procedure, if the pesticide label and/or manufacture's guidelines are unavailable, for cleaning equipment prior to storage at the end of the season:

Step 1: Hose down the inside of tank completely, fill to half full and flush the system by operating the sprayer.

Step 2: Repeat Step 1.

Step 3: Remove nozzle tips and screens and clean them using a soft brush and kerosene or detergent water.

Step 4: Fill the tank full and add 1 pound of detergent for every 50 gallons of water. Circulate through the bypass pressure regulator and jet agitator for 30 minutes. Flush solution through the nozzles.

Sprayers that have contained phenoxy type herbicides, such as 2,4-D or organophosphate insecticides should be cleaned by the following procedure prior to Step 5:

- ➡ replace the screens and nozzle tips,
- ➡ fill tank half full of water, add 1 pint of ammonia for every 25 gallons of water,
- ➡ circulate solution for about 5 minutes, then discharge a small amount of solution through nozzles,
- ➡ keep remaining solution in sprayer at least 4 hours, preferably over night, and
- ➡ flush remaining solution through the nozzles.

Step 5: Fill the tank half full of clean water, hose down the outside and inside, then flush through the nozzles.

Step 6: Remove tips, discs, strainers, and screens and store in light oil. Store sprayer in a clean, dry structure. If the pump cannot be drained completely, store where it cannot freeze. Oil films should be applied to some types of tanks and possibly the pumps to prevent rusting.

Other *preventative measures* include:

- ✓ Overhaul pumps yearly during the winter.
- ✓ Protect steel tanks with a light coat of oil or kerosene.
- ✓ Oil or paint coats inside the tank should be those approved for such use.
- ✓ Avoid leaving pesticides in the tank for extended periods of time.
- ✓ Hoses used for chemicals can never be decontaminated; don't use them for drinking water.
- ✓ Caustic soda (lye) is corrosive to aluminum parts so should not be used as a rinse in aluminum tanks.
- ✓ Don't start a pump against pressure; use the proper relief valves.
- ✓ Always consult the manufacturer's recommendations.

♦ **Aerial Equipment**

The subject of aerial spray equipment and accessories is a complex subject suitable for engineers and experienced pilots; however, many aspects of aerial application are similar to ground application. For example, sprayers are basically constructed of the same components. Calibration is accomplished in much the same way except that speeds are much greater and rates much lower. For more information on aerial spraying contact the National Agricultural Aviation Association, 1005 E Street SE, Washington, DC 20003; phone number: 202-546-5722.

Types of Aircraft

There are several classes of aircraft that may be utilized for the application of pesticides. These classes include:

- ◆ *High wing monoplanes* are not primarily designed for applying pesticides, but do provide good visibility, handling, and low maintenance cost.

- ◆ *Low wing monoplanes* provide increased safety by providing better visibility, stability, and protection to the pilot.
- ◆ *Multi-engine* aircraft are utilized extensively in forest and rangeland application.
- ◆ *Helicopters* have some advantages over fixed wing aircraft, i.e. operate at slower speed; increased safety; improved accuracy of swath, coverage, and placement of the chemical; and they may be operated without airport facilities.

Drift

A serious problem associated with aerial and ground application of pesticides is drift of pesticides to nontarget areas. However, aerial application have more features that add to the drift problem:

- The requirement of low application rates means that spray droplets must be small so that coverage (droplets per acre) will be adequate. Smaller droplets have a greater tendency to drift; droplets 30 microns and smaller remain suspended in air. Spray droplets should be about 100 microns to minimize drift. Table 5.2 gives an indication of the effect of droplet size on drift.

Table 5.2

| Spray Droplet Size and Its Effect on Spray Drift | | | |
|--|------------------------|--------------------------|---|
| Spray Droplet Diameter (micron*) | Particle Type | Similar Weather Elements | Distance Droplet Moved (by 3 MPH wind in 10 ft. fall) |
| 400 | coarse aircraft spray | light rain | 8.5 feet |
| 150 | medium aircraft spray | mist | 22 feet |
| 100 | fine aircraft spray | -- | 48 feet |
| 50 | air carrier spray | -- | 178 feet |
| 20 | fine sprays & dusts | fog | 1,109 feet |
| 10 | usual dusts & aerosols | -- | 4,435 feet |
| 2 | aerosols | -- | 21 miles |

* 1 micron is about 1/25,000 inch

-- From Akesson & Yates, *Ann. Rev. Entom.* Vol. 9, 1964

- Pesticides are generally released at greater heights than from conventional sprayers. This is done to achieve good coverage, but may result in pesticide drift caused by wind, convection currents, and aircraft turbulence.

Aerial applications should be conducted when the air movement is predictable and consistent (3-5 mph). By spraying early in the morning, convection currents which form at temperatures 85° F and above can be avoided.

The flight path directly affects the amount of drift. If the aircraft is climbing, there will be more down push and less spray pulled into vortices. If the aircraft is descending, the wing or rotor tip vortices will pull more spray aloft; various portions of the spray pattern will be disturbed as well. Level or slightly ascending flight is usually best to alleviate both effects. The following factors can help to reduce pesticide drift:

- ✓ Increase droplet size by the use of invert emulsions (water in oil mixtures), viscosity additives, or foam producing additives.
- ✓ Increase droplet size by using nozzles with larger orifices or by using a jet nozzle.
- ✓ Limit boom length to no more than 3/4 of the wing span.
- ✓ Control droplet size by using the correct pressure.
- ✓ Use atomizers (spinners) at the proper rpm.
- ✓ Fly at the proper altitude.
- ✓ Apply pesticides early in the day before convection currents form.
- ✓ Spray only when winds are less than 10 mph.
- ✓ Choose pesticide formulations that are not volatile.
- ✓ Reduce air shear across nozzles.

Tests show that there is an increase in drift with more swaths. Barriers near the target area (trees) may help reduce drift and confine it to the target area. For a look at how different factors affect drift, see the following table.

| The Effect of Various Factors on Pesticide Drift | | |
|---|--|--|
| Drift Factors | More Drift | Less Drift |
| aircraft altitude | higher altitude | lower altitude |
| wind speed | faster | slower |
| droplet size * pressure * nozzle capacity * orifice size * orifice shape * air shear on spray * surface tension * spray density * viscosity | smaller higher smaller smaller sharp angles higher lower lower lower | larger lower greater larger round lower higher higher higher |
| vertical air motion | up | down |
| air stability | greater | reduced |
| aircraft speed | faster | slower |

Equipment for Dispersing Pesticides

Application equipment can be constructed for dispersing dry or liquid pesticides. Since applicators can be asked to apply either type, equipment such as hoppers are often constructed so that liquid or dust formulations can be applied. Following is a discussion of equipment for aerial application of liquid and/or dry pesticides in fixed wing or rotary wing aircraft.

✓ Dry Material Application Systems

In a *fixed wing aircraft*, chemicals are dispensed primarily by:

- ◆ A *ram-air spreader* in which dry materials are metered from the hopper into the propeller slip stream. Ram-air systems do not have the capacity to spread materials in a wide swath. This led to the development of spinners.
- ◆ *Spinners* consist of spinning vanes mounted under the hopper that throw material outward in a uniform pattern. Some equipment, to further increase spreading power, utilizes a blower to force material into the spreader. The use of spreaders and blowers can nearly double the swath width.

In *helicopters*, two types of dispensers are used:

- ◆ A blower, driven by the engine, forces material from two side tanks and out short booms. The material may be spread using spinners instead of the boom.
- ◆ A single hopper can be suspended on a cable and material dispensed using spinners. This method eliminates the problem of aircraft trim caused by uneven emptying of side tanks. Agitators, to insure even dissemination of material from the tanks, may or may not be present. They are essential for materials smaller than 60 mesh. Their use will help insure even application by providing an even flow of material.

The hopper or tank for dry materials should have many of the characteristics of a tank for holding liquids. Corners should be rounded and the sides should be steep to insure complete unloading of the chemical. Usually a slope of 50° to 55° is adequate. Tanks can often be used for dry or liquid materials by replacing a bolt-on plate on the tank bottom with a hopper.

✓ Liquid Material Application Systems

There are two types of spray systems for fixed and rotary wing aircraft:

- ◆ *pressure type* - the spray is applied under specific pressures.
- ◆ *gravity feed* - the flow of spray solution from the tank to dispersing unit relies upon gravity. Aircraft spray dispersal equipment consists of a tank(s), pump(s), pressure regulator, line filter, flow control valve, boom and nozzles. Swath widths of 40 to 60 feet, in the application range of 1 to 10 gallons per acre are normal when material is released 5 to 8 feet above the ground.

☞ **Tanks** for fixed wing aircraft are usually mounted internally, often ahead of the pilot and aft of the engine, however, quick release belly tanks can be mounted to the aircraft bottom. This permits rapid jettison of the tank, should the need arise. Also, aircraft not primarily used for spraying can be modified to do so.

- ✓ In rotary wing aircraft, tanks are mounted externally on the side or underneath.
- ✓ All tanks should have emergency dump valves located on the tank bottom. Internal baffles are required to prevent rapid shifts in fluid.

☞ Two types of **agitation systems** are utilized to maintain suspensions and mixtures of chemical. **Mechanical systems** rely on paddles to maintain agitation. **Hydraulic systems** utilize a return flow from a large capacity pump. A rule of thumb is that the flow rate should be 10 GPM for every 100 gallons of tank capacity.

☞ The most common **pump** is that driven by a small propeller in the slip stream of the aircraft engine propeller. The efficiency of this type of pump is low and many newer aircraft are equipped with hydraulic piston pumps or electric pumps.

Helicopter pumps are usually driven by a PTO. Centrifugal pumps are the most common type where application rates are 1-10 gal./acre. Where higher pressures are needed, as for aerosols, or where pump discharge is greatly reduced, other pump types such as gear or roller are used.

☞ **Pressure regulators** or by-pass relief valves are utilized to maintain a constant spray pressure. Pressure regulators are located between the pump and boom and include a quick closing shut-off valve. These valves allow the spray system to be opened and closed instantly.

☞ The **main control valve** is usually 3-way. In the "spray off" position, the valve directs flow from the pump back into the tank. This action maintains a slight vacuum in the boom to prevent pesticide dribble, and provides recirculation agitation in the tank. A third valve position allows the tank to be filled or emptied through the boom.

☞ **Screens or filters** are generally located in three places in liquid systems. A coarse screen at the tank bottom keeps debris from entering the pump. The most important screen is one located between the pump and the booms. It is usually 25 to 100 mesh (10-40 openings per centimeter) and can be removed easily for cleaning. Mesh size depends upon nozzle orifice size so that particles that might plug the nozzles can be removed. A third screen is usually placed just before each nozzle orifice.

☞ **Pipes and fittings** usually have the following characteristics that help prevent pressure losses:

- ✓ For application rates over 2 gallons per acre, all main piping and fittings are 1-1/2 inches inside diameter.

- ✓ For application rates of $\frac{1}{2}$ to 2 gallons per acre, all main piping and fittings are at least 1 inch inside diameter.
- ✓ For ultra low volume (ULV) applications, hoses to individual nozzles should be 1/8 inch inside diameter. Main line hoses and fittings should be at least 3/8 inch inside diameter.

The number of bends and joints should be minimized. All hose connections should be double clamped and lines under pressure should not run through the cockpit.

☞ **Booms** for fixed and rotary wing aircraft, although mounted differently, are basically the same in construction. Boom pipes are round or aerodynamic in cross section. In fixed wing aircraft, they are mounted on the trailing edge of the wing and usually are 3/4 the wing span length.

☞ **Nozzles** used in aerial spraying are basically of 4 types:

- ✓ The jet or solid stream nozzle produces a jet of coarse droplets useful for coarse sprays such as 2,4-D.
- ✓ Hollow cone nozzles, identified because of their spray pattern, produce small droplets.
- ✓ The flat fan nozzle produces a fan shaped pattern and is useful in reduced volume applications.
- ✓ An atomization nozzle produces a true aerosol spray in a cone shaped pattern.

☞ **Atomizers**, in addition to the atomizing nozzle, include a variety of spinning screen cages, discs, and wire brushes. They are usually driven by fans or electric motors. Atomizers produce droplets of more uniform size and are useful in low volume spraying such as grasshopper or mosquito control. Droplet size is influenced by a complex interaction among pressure, spinner speed, air shear, and discharge angle. For example, as pressure (flow rate) increases, droplet size increases. As spinner velocity increases, droplet size decreases. The angle of discharge from the nozzle in relation to the airstream influences droplet size. Smaller sized droplets will be produced if nozzle discharge is directed at 90° relative to the slip stream.

Safety and Maintenance

The safety section in this manual also applies to aerial applicators. The following additional rules also apply:

- ▲ Because pilots may fly through previous swaths, a clean air supply is necessary. If a filtered air helmet or cockpit is not available, use an approved respirator.
- ▲ No hoses, valves, or any portion of the system carrying pesticides should pass through the cockpit.
- ▲ Components of the spray system inside the fuselage should be accessible for cleaning, maintenance, and repairs.

- ▲ The critical demands of aerial pesticide application require regular maintenance. The seasonal nature of pesticide application lends itself to inspections and repairs during idle periods.

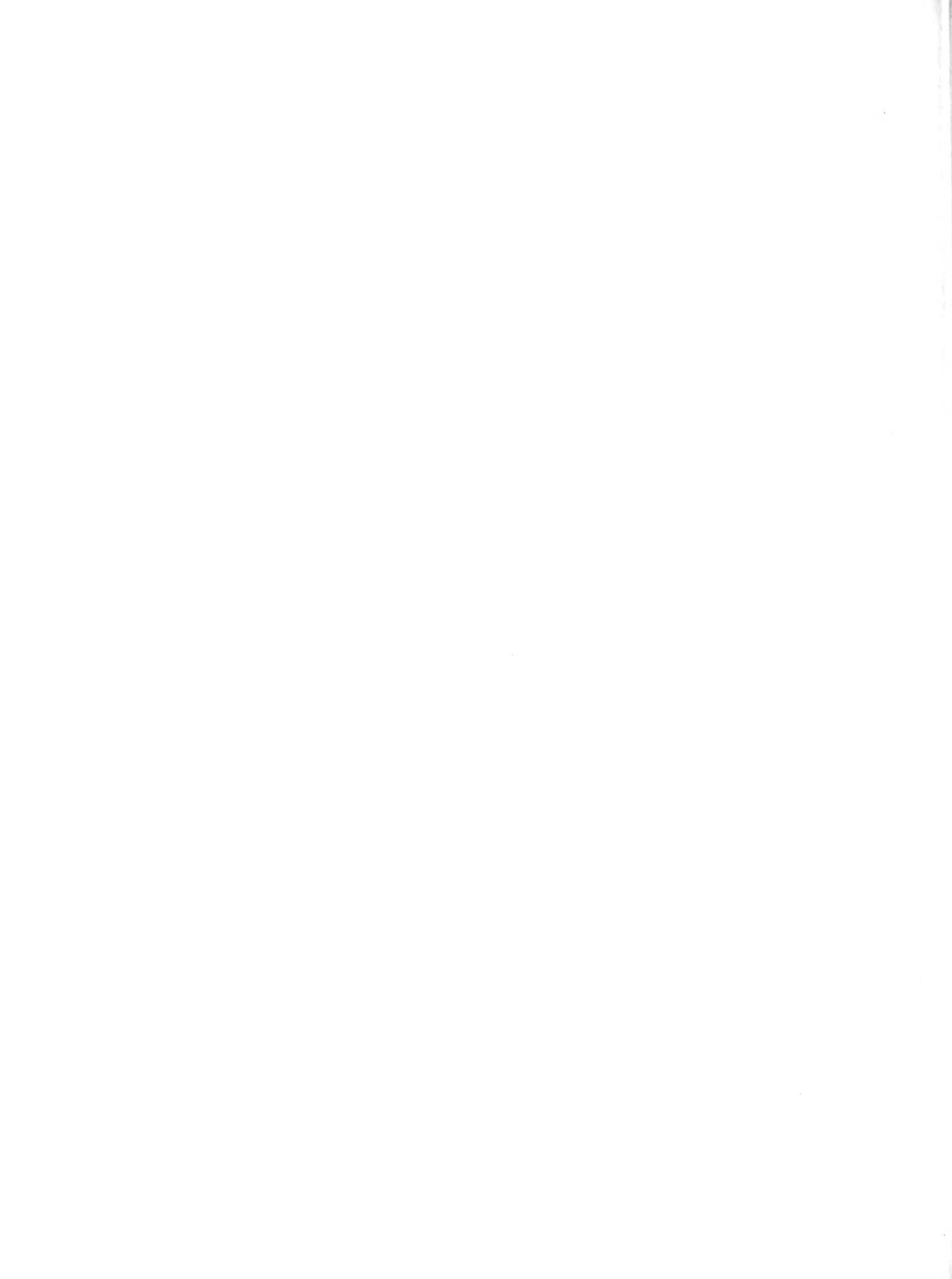
ULV Application

Some pesticide applications apply highly concentrated material at low rates. Ultra low volume (ULV) rates for mosquito control are as low as 0.1 gallon per acre. The application of ULV formulations requires the use of special equipment and application procedures. Conventional aircraft spray systems can be modified to accommodate ULV formulations. A small ULV system can be installed separate from the dilute system and can be removed upon completion of ULV operations.

The following points should be observed when applying ULV applications: ULV systems must deliver fine droplets to be effective. This can be accomplished by utilizing spinning or flat fan nozzles discharging 0.1 GPM or less at 40 to 55 psi. Gaps in the distribution pattern can be avoided by using not less than four flat fan nozzles. For helicopter operations, a single spinning nozzle may provide adequate output at very low rates, such as required for mosquito control.

Because of the fine droplets produced by ULV systems, the location of the nozzles is important. Extreme outboard nozzles must be located away from the wing tips on fixed wing aircraft to avoid spray entrapment in the wing tip vortices. Central nozzles can be shifted to the right to compensate for propeller wash. ULV application should be made at the altitude that will achieve the optimum spray width strip. As wind velocity increases, the aircraft altitude should decrease.

Carriers used in ULV formulations may cause premature wearing of certain equipment parts. For instance, the carrier for Malathion will corrode rubber and neoprene. To minimize chemical damage to spray equipment seals, hoses, and nozzle diaphragms should be checked regularly and replaced if corrosion has begun. Nozzle screens should also be checked regularly, since the smaller tips become clogged more easily.



CHAPTER VI

CALIBRATING PESTICIDE EQUIPMENT

The performance of any pesticide depends on the proper application of the correct amount of chemical. A wide variety of sprayers are available for applying herbicides, insecticides and fungicides, however, they must be calibrated accurately to obtain effective pest control. Accurate calibration ensures that the correct amount of pesticide is applied uniformly over the target area.

Calibration includes:

- ❖ Calculating the amount of product to be used;
- ❖ Mixing the product properly and safely;
- ❖ Calibrating the spray equipment for the desired rate uniformly across the spray swath;
- ❖ Determining the most effective swath width and overlap;
- ❖ Checking accuracy during operation; and
- ❖ Detecting and correcting errors.

Four major benefits of calibration are:

- ❶ **Effective pest control.** Underapplication of a pesticide may result in ineffective pest control, requiring a second application to achieve the desired level of control. Underapplication may also result in pest resistance.
- ❷ **Environmental and human safety.** Applying more pesticide than required may result in excessive or illegal residue in the harvested crop, damage to the crop or nontarget species, and increased risk of contaminating ground water, surface water or soil.
- ❸ **Effective use of time.** Additional applications because of inadequate pest control from the initial treatment require extra time and cost to the applicator.
- ❹ **Best cost/benefit ratio.** Over the years the cost of pesticides has steadily risen. Over application by 15% of an herbicide costing \$9.00 per acre increases the cost by \$1.35 per acre. For a 200 acre field, this increases the chemical costs by \$270.00, with no extra pest control benefit.

Variables affecting application rates are:

- ❖ **Ground Speed or Miles Per Hour (MPH).** Application rates vary inversely with the ground speed. Field speed should be identical to calibration speed. Increasing speed during application lowers the application rate, while decreasing speed increases the application rate. For example: doubling application speed decreases the application rate by one-half, whereas decreasing the application speed by one-half doubles the application rate.
- ❖ **Nozzle Flow Rate or Gallons Per Minute (GPM).** The flow rate through the nozzle varies with the size of the nozzle tip. The larger the nozzle opening, the greater the nozzle output. Nozzle flow rate is also affected by pressure.

- ❖ **Pressure.** Nozzle flow rate varies proportionally with the square root of pressure. That is, the flow rate increases with increasing pressure, but a doubling of pressure does not double the flow rate. Doubling the flow rate of the spray solution would require the pressure to be increased four times. Pressure cannot be used to make major changes in application rate, but it can be used to effect *minor* changes due to nozzle wear and other factors. However, when adjusting pressure to effect flow rate changes, operating pressure must be maintained within the recommended range for each nozzle type to ensure a uniform spray pattern and minimize drift hazard.
- ❖ **Nozzle Spray Width or Spacing (W).** The effective width sprayed per nozzle also affects the application rate. Doubling the effective spray width per nozzle decreases the gallons per acre applied by one-half.
- ❖ **Nozzle Wear.** Worn spray tips may over apply pesticides, possibly causing nontarget or crop damage and resulting in excess chemical costs. Clogged tips or screens can result in under-application and lessen the effectiveness of your spraying program. Improper cleaning can damage nozzle tips enough to cause widely erratic spray patterns.
- ❖ **Viscosity of Spray Solution.** Calibration solution viscosity should be equivalent to the spray solution viscosity. Wettable powders generally have a higher viscosity than water while oil-based solutions will have a lower viscosity than water. Spraying with a different viscosity solution than was calibrated with, will change the application rate. The greater the viscosity difference, the greater the difference in application rate from calibration rate.

The gallons of spray applied per acre (GPA) can be determined from the three variables GPM, MPH and W by using the following formula:

$$GPA = \frac{GPM \times 5940}{MPH \times W}$$

GPM = Output per nozzle in gallons per minute.

MPH = Ground speed in miles per hour.

W = Sprayed width per nozzle, or nozzle spacing in inches.

5940 = A constant to convert gallons/minute, miles/hour and inches to gallons /acre.

Using these variables when calibrating your sprayer allows you to pre-select the gallons to apply per acre and complete most of the calibration before going to the field. It also provides a simple method of frequently checking the calibration for changes, such as nozzle wear. It can be used for broadcast, band, directed and row-crop spraying. This method does require a knowledge of nozzle types and sizes and the recommended operating pressure ranges for each type of nozzle used.

Once the proper nozzle type has been selected, the correct nozzle tip size must be chosen. The size of tip selected will depend on the application rate per acre (GPA), ground speed (MPH) and spray width (W) you plan to use. Some nozzle tips are rated in gallons per acre. Such ratings, however, are based on a specific speed and pressure. The best way to select the nozzle tip size is by gallons

per minute (GPM). This lets you make the decisions on spraying based on your field and plant conditions. The following steps should be considered when selecting the correct size:

- ▶ Determine the application rate in gallons per acre (GPA) from the pesticide label. The spray application rate is the gallons of carrier plus the pesticide applied per treated acre.
- ▶ Select or measure an appropriate ground speed in miles per hour (MPH) according to existing field conditions. You should not rely on a speedometer as an accurate measure of speed. Slippage and variation in tire sizes can result in speedometer errors of 30 percent or more. If actual ground speed is not known, it can easily be measured. The procedure is described on page 72 in this chapter.
- ▶ Determine the spray width per nozzle in inches (W). For broadcast spraying, W equals the nozzle spacing. For band spraying, W equals the band width. For row-crop applications using multiple nozzles per band:

$$W = \frac{\text{row spacing / band width}}{\text{number of nozzles per row / band}}$$

- ▶ Determine the flow rate required from each nozzle in gallons per minute (GPM) by using the following equation: *note - 5940 is just a constant number.

$$GPM = \frac{GPA \times MPH \times W}{5940}$$

- ▶ Using a flow rate table from the nozzle manufacturer, select a nozzle that will give the flow rate determined when operated within the pressure range at which you will be operating.

Example:

Nozzle Type - Flat Fan, 80° angle

Nozzle Spacing - 20 inches

GPA - 20 gallons

Speed - 6 MPH

Pressure - 30 psi

$$GPM = \frac{20 \text{ GPA} \times 6 \text{ MPH} \times 20 \text{ inches}}{5940} = 0.40$$

Check the nozzle manufacturer for a flat-fan nozzle that delivers 0.40 gallons per minute at 30 psi pressure.

► Sprayer Calibration

Pre-calibration Check: Make sure the spray system is clean; install nozzle tips determined for correct flow rate; partially fill spray tank with water; operate sprayer within recommended pressure range; place a container under each nozzle to determine variations in flow rate, replace any nozzle that is 5 percent more or less than the average of all nozzles; check nozzle spray angle, nozzle spacing and nozzle height needed to obtain uniform coverage.

Calibration: Determine the required flow rate for each nozzle in ounces per minute (OPM).

$$OPM = GPM \times 128 \text{ fl.oz./gal.}$$

Example:

Required nozzle flow rate = 0.40 GPM

$$OPM = 0.40 \times 128 = 51 \text{ fl.oz.}$$

Collect the output of each nozzle in a container graduated in fluid ounces, each nozzle should deliver the same rate; adjust pressure to make minor nozzle flow rate changes to equal OPM; make sure pressure remains within the recommended range for the nozzle.

► Ground Speed Measurement

Ground speed must be accurately determined for correct application of pesticides. You should not rely on the speedometer as an accurate measurement of speed. To measure ground speed, lay out a known distance in the field to be sprayed. At the engine throttle setting or RPM and gear you plan to use during spraying and with the sprayer filled one-half to three-quarters full, determine the travel time between the measured stakes, traveling each direction. Average these two times and use the following equation to determine travel speed: **note - 60 and 88 are just constant numbers.*

$$MPH = \frac{Distance \text{ (feet)} \times 60}{Time \text{ (seconds)} \times 88}$$

Example:

$$\frac{176 \text{ feet} \times 60}{20 \text{ seconds} \times 88} = 6 \text{ MPH}$$

Ground speed may also be determined by setting a known course length of 100, 200 or 300 feet, determining the travel time as above, then referring to the following table:

| Ground Speed (MPH) | Time in Seconds Required to Travel: | | |
|-----------------------|-------------------------------------|-----------|-----------|
| | 100 feet | 200 feet | 300 feet |
| 3.0 | 23 (sec.) | 45 (sec.) | 68 (sec.) |
| 3.5 | 20 | 39 | 58 |
| 4.0 | 17 | 34 | 51 |
| 4.5 | 15 | 30 | 45 |
| 5.0 | 14 | 27 | 41 |
| 6.0 | -- | 23 | 34 |
| 7.0 | -- | 19 | 29 |
| 7.5 | -- | 18 | 27 |
| 8.0 | -- | 17 | 26 |

Once you have decided on a particular speed, record the throttle tachometer setting and drive gear used so they may be duplicated in the future.

► Amount of Pesticide Needed Per Tank

To determine the amount of pesticide to add to the spray tank, you need to know the recommended rate of pesticide per acre, the capacity of the spray tank and the calibrated output of the sprayer. The application rate of pesticide is determined from the label. The rate is usually given as pounds per acre for wettable powders, and ounces, pints or quarts per acre for liquids. Sometimes the recommended rate is given as pounds of active ingredient (a.i.) per acre rather than the amount of product per acre. The active ingredient must then be converted to actual product amount per acre.

Example 1:

Recommended rate per acre - 2 lbs. a.i.

Product used - 80 % wettable powder (W.P.)

Tank capacity - 400 gallons

Gallons per acre - 20

$$\frac{400 \text{ gal (tank capacity)}}{20 \text{ GPA}} = 20 \text{ acres/tank}$$

$$\frac{2 \text{ lbs. a.i.}}{80\% \text{ W.P.}} = \frac{2}{.80} = 2.5 \text{ lbs. W.P./acre}$$

Example 2:

Recommended rate per acre - 1 lb. a.i.
Product used - 4 lbs. a.i. per gallon
Tank capacity - 300 gallons
Gallons per acre - 15

$$\frac{300 \text{ gallons}}{15 \text{ GPA}} = 20 \text{ acres/tank}$$

$$20 \text{ acres/tank} \times 1 \text{ lb. a.i./acre} = 20 \text{ lbs./tank}$$

$$\frac{20 \text{ lbs. a.i./tank}}{4 \text{ lbs. a.i./gallon}} = 5 \text{ gallons/tank}$$

► **Adjutants (Surfactants)**

The application of some pesticides require a surfactant be used to provide optimum control. The rate recommended is given as a certain volume per gallons of water or as a percent of total volume used.

Example 1:

Recommended rate - 1 pint per 100 gallons of spray
Tank capacity - 300 gallons

$$\frac{300 \text{ gallon tank}}{100 \text{ gallons of spray}} = 3 \text{ pints/tank}$$

Example 2:

Recommended rate - 1/2% of volume used
Tank capacity - 300 gallons

$$300 \text{ gallon tank} \times 0.005 = 1.5 \text{ gallons/tank}$$

► **1/128 Calibration Method**

This method of sprayer calibration gives sprayer output in gallons per acre when the nozzle discharge is measured in ounces for a course length determined from Table 6.1 on the next page. This works because one gallon equals 128 ounces and the test area for which the output is measured is 1/128 of an acre. The 1/128 method can be used for boom sprayers and backpack/handgun sprayers. The procedures to calibrate each type of sprayer are detailed below.

Boom Sprayers

Adjust the sprayer to the pressure that will be used for application and check for uniformity in nozzle output by measuring spray from each nozzle for a set time. Clean or replace any nozzle tip that varies by 5 percent or more from the output of a new nozzle.

Table 6.1

| Nozzle Space (inches) | Distance (feet) |
|--------------------------|--------------------|
| 40 | 102 |
| 38 | 107 |
| 36 | 113 |
| 34 | 120 |
| 32 | 127 |
| 30 | 136 |
| 28 | 146 |
| 26 | 157 |
| 24 | 170 |
| 22 | 185 |
| 20 | 204 |
| 18 | 227 |

Measure the band width or nozzle spacing in inches. Referring to the table at left, select the corresponding calibration distance in feet, according to your nozzle spacing, and mark this distance off in the area you will be spraying.

With the spray tank one-half to three-quarters full of water, drive the marked distance at your normal spraying speed. Start driving far enough before the beginning of the course to ensure you reach operating speed before you begin timing. Next, using a container graduated in ounces, operate the sprayer at the same pressure used when operating, and collect the output from any nozzle for the same amount of time it took to drive the calibration distance. The ounces of water collected equals the gallons per acre applied.

Example 1:

The pressure you are using is 30 psi. The nozzles are spaced 20 inches apart on the boom.

- The distance to mark off for the 20 inch nozzle spacing is 204 feet.
- Select the gear and throttle setting, bring the sprayer up to speed and measure the time needed to cover 204 feet.
- If it required 30 seconds to travel the 204 feet, set the pressure at 30 psi and catch the output of one nozzle for 30 seconds.
- Measure the amount collected. The output in ounces is the amount applied in gallons per acre. If the nozzle output is 20 ounces, the sprayer applied 20 gallons per acre.

$$\frac{\text{tank capacity}}{\text{GPA}} = \text{acres/tank}$$

Tank capacity - 200 gallons
Spray rate - 20 gallons per acre

$$\frac{200 \text{ gal.}}{20 \text{ GPA}} = 10 \text{ acres/tank}$$

Handgun and Backpack Sprayers

Measure out an area $18\frac{1}{2}$ by $18\frac{1}{2}$ feet. This equals 340 square feet or approximately 1/128 of an acre. Adjust the sprayer to the desired pressure and spray pattern and measure the time it takes to spray the test area. Repeat this several times and take the average time. Using a container graduated in ounces, spray into the container for the same amount of time it took to spray the measured area. The amount collected in ounces equals the application in gallons per acre.

Example:

- ➡ Measure area. $18\frac{1}{2}$ ft. \times $18\frac{1}{2}$ ft. = 340 ft² \approx 1/128 acre.
- ➡ Time to spray area = 146 seconds.
- ➡ Spray into container for 146 seconds.
- ➡ Amount collected = 73 ounces.

Therefore: 73 ounces in container = 73 gallons per acre application rate.

Common Problems and Possible Causes When Calibrating

| Problems | Causes |
|--|--|
| Streaks or voids in spray pattern | Clogged or damaged tip; incorrect nozzle height. |
| Nozzle spray pattern is narrow and/or heavier in the middle and/or edges. | Tip worn enough to cause uneven application and should be replaced. |
| A sprayer tankful covers <u>more</u> acres than before at the same pressure and speed. | Clogged tips or screens; faster field speed due to less wheel slippage; pump losing capacity/volume. |
| A sprayer tankful covers <u>fewer</u> acres than before at the same pressure and speed. | Worn spray tips; slower field speed due to more wheel slippage; leaks through hoses or connections. |
| Measured GPM noticeably <u>less</u> than from a new tip of the same size at the same pressure. | Clogged tips or screens. |
| Measured GPM noticeably <u>more</u> than from a new tip of the same size at the same pressure. | Spray tip is worn severely enough that is should be replaced. |
| Streaks of weeds or crop damage. | Uneven application because of: worn spray tips; a wrong size tip; clogged tips or screens; incorrect spray pattern overlap; boom height adjusted too low; boom not parallel to the ground. |

♦ Calibration of Aerial Equipment

The same variables that apply to ground equipment also apply to aerial calibration, i.e. speed, pressure, nozzle spacing, and swath width. Aerial applicators should be familiar with the sections in this manual dealing with ground equipment and accessories, ground equipment calibration and maintenance. Precise calibration is essential in order to apply the correct rates and to guard against crop injury caused by overdoses of pesticide.

Swath width must be known for accurate calibration. Because aircraft wheels nearly touch the crop during application, swath width is about the same as boom width or is related to the ram-air or spinner type spreader.

To make a precise measure of swath width, flights can be made over collecting surfaces arranged in a line perpendicular to the line of flight. Dyed sprays can be deposited on cards or plastic plates and the amount of pesticide or liquid deposited can be measured. Deep baskets or buckets or oiled surfaces can be used to collect granules. From the information gathered, swath width and deposit pattern can be determined. Be sure to determine effective swath width, or that swath width in which pesticide was deposited in sufficient quantity to give control.

When air speed and swath width are known, the rate at which pesticides should be dispensed can be found using this formula:

**note - 495 is just a constant number.*

$$\text{Rate (GPM)} = \frac{\text{Label rate (GPA)} \times \text{swath width} \times \text{air speed}}{495}$$

For example, the 100 mph aircraft has a 40 foot effective swath width. Label rate instructions call for 10 GPA.

At what rate should the aircraft be calibrated?

$$\frac{10 \text{ gal./acre} \times 40 \text{ ft.} \times 100 \text{ mph}}{495} = 80.8 \text{ gal./min}$$

For dry materials, the discharge rate thus obtained can be established by actual flight tests for ram-air spreaders. Spinners can be calibrated by operating the equipment on the ground.

For liquid pesticides, the discharge rate can be obtained by selecting nozzle type and size. The number of nozzles on the boom can be adjusted to give the proper discharge rate to determine the correct number of nozzles, use the following formula:

$$\text{No. Nozzles} = \frac{\text{Discharge rate (GPM)}}{\text{Flow rate / nozzle (GPM)}}$$

For example, flow rate should be 80.8 GPM and the flow rate for the nozzles selected is 6.7 GPM.

How many nozzles will give the proper flow rate?

$$\frac{80.8 \text{ GPM}}{6.7 \text{ GPM}} = 12 \text{ nozzles}$$

(Small alterations in discharge rate can be made by adjusting pressure.)

To determine the number of acres that can be treated with one tank or hopper, use this formula:

$$\text{Total acres} = \frac{\text{Tank size (gal.)}}{\text{Rate / acre (GPA)}}$$

As a final check on calibration, it is desirable to make an actual flight check. After the tank is filled with a known quantity or to a marked level, a flight of a given time or distance is made. The amount of material applied can then be determined by filling the tank to its original level. The quantity applied per acre can be determined and will indicate the accuracy of calibration. Table 6.2 provides a quick reference for determining acreage sprayed for a given swath width and field length.

Table 6.2

| Field Length | Swath Width (feet) | | | | | | | | | | | | |
|----------------------|--------------------|------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| | 20 feet | 25 feet | 30 feet | 35 feet | 40 feet | 45 feet | 50 feet | 55 feet | 65 feet | 75 feet | 85 feet | 95 feet | 100 feet |
| 1320 ft. 1/4 mile | 0.6 acres | 0.75 acres | 0.9 acres | 1.1 acres | 1.2 acres | 1.4 acres | 1.5 acres | 1.7 acres | 2.0 acres | 2.3 acres | 2.5 acres | 2.9 acres | 3.0 acres |
| 2640 ft. 1/2 mile | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3.0 | 3.3 | 3.9 | 4.5 | 5.1 | 5.7 | 6.1 |
| 3960 ft. 3/4 mile | 1.8 | 2.3 | 2.7 | 3.2 | 3.6 | 4.1 | 4.6 | 5.1 | 5.9 | 6.8 | 7.7 | 8.7 | 9.1 |
| 5280 ft. 1 mile | 2.4 | 3.05 | 3.6 | 4.2 | 4.8 | 5.5 | 6.1 | 6.7 | 7.8 | 9.1 | 10.2 | 11.2 | 12.1 |
| 2 miles | 4.9 | 6.05 | 7.2 | 8.4 | 9.8 | 10.9 | 12.1 | 13.3 | 15.6 | 18.2 | 20.8 | 23 | 24.2 |
| 3 miles | 7.2 | 9.1 | 10.8 | 12.6 | 14.5 | 16.4 | 18.2 | 20 | 23.4 | 27.3 | 30.8 | 34.6 | 36.4 |
| 4 miles | 9.7 | 12.1 | 14.4 | 16.8 | 19.4 | 21.8 | 24.2 | 26.6 | 31.2 | 36.4 | 41.2 | 46 | 48.5 |
| 5 miles | 12.1 | 15.1 | 18 | 21 | 24.2 | 27.3 | 30.3 | 33.3 | 39.3 | 45.5 | 51.4 | 57.6 | 60.6 |

Acre = (length in feet x width in feet/43,560)

CONVERSION FACTORS FOR UNITS OF MEASUREMENT

Units of Volume - Liquid Measure

3 teaspoons = 1 tablespoon

2 tablespoons = 1 fl. ounce

8 fl. ounces = 1 cup

2 cups = 1 pint

2 pints = 1 quart

4 quarts = 1 gallon

1 kiloliter = 1000 liters = 164.2 gallons

1 liter = 1000 milliliters = 1.06 quarts

1 milliliter = 1000 microliters = 0.03 fl. ounces

Units of Length

1 inch = 2.54 centimeters

12 inches = 1 foot

3 feet = 1 yard

16.5 feet = 1 rod

1760 yards = 1 mile

1 mile = 5280 square feet

1 kilometer = 1000 meters = 0.62 miles

1 meter = 10 decimeters = 39.37 inches

Units of Area

1 square foot = 144 sq. inches

1 square yard = 9 sq. feet

1 square rod = 30.25 sq. yards

1 acre = 160 sq. rods

1 acre = 43560 sq. feet

1 hectare = 10,000 sq meters = 2.47 acres

1 sq. meter = 100 sq. decimeters = 1.20 sq. yards

Units of Mass (metric and Avoirdupois)

16 ounces = 1 pound = 0.45 kilograms (kg).

2000 pounds = 1 ton = 907.2 kg

1 kilogram = 1000 grams = 2.2 pounds

1 gram = 1000 milligrams = 0.35 ounces

CHAPTER VII

PESTICIDE STORAGE, TRANSPORTATION AND DISPOSAL

► Pesticide Fire and Explosion Hazards and Precautionary Guidelines

Read the label when storing any pesticide and store each chemical in accordance with directions to prevent fires and explosions. Many users of pesticides are aware of the contamination and public health hazards when applying chemicals, but do not recognize hazards from chemical fires. Fire prevention in pesticide storage areas should be an important part of planning storage structures and sites.

Pesticides containing oils will burn readily or the containers will explode when over-heated. Some solvents used as carriers are highly flammable and explosive. Fumes and smoke from chemical fires can be highly toxic to fire fighters and residents in the area. Herbicide "smoke" can also be phytotoxic to nearby plants.

Inform local police, fire departments, and public health officials in writing of the location and layout of the storage area, type of materials stored, and hazards involved. Provide phone numbers of persons responsible for storage to the fire chief. Fire departments should have a map with locations of all pesticide storage facilities in their areas. Inform local physicians and hospitals of potential hazards and be sure they know how to treat poisonings caused by stored pesticides.

Identify pesticide storage areas with prominent, water-proof signs over each entrance, including any windows. Storage entrances should always be locked when not in use. If a fire occurs, call Disaster Emergency Services (DES) or firemen and protect nearby residents by evacuating those down-wind. The state DES coordinator will contact the MDA and other appropriate agencies. After the fire is out, the contaminated area should be roped off and supervised continuously until cleanup is completed.

Cleanup procedures after the fire should be handled by persons familiar with pesticides and their hazards. Notify all local public health officials so correct decontamination procedures will be followed. Check with pesticide manufacturers for additional advice and use of their expert decontamination team, if necessary.

The Chemical Transportation Emergency Center has a program to provide emergency information to fire and police crews responding to transportation accidents and fires involving hazardous chemicals. Provide the CHEMTREC emergency number to your local fire and police departments.

CHEMTREC
emergency number is:
800/424-9300.

► **Pesticide Storage**

Pesticides should be stored in dry, locked, well ventilated areas where humans, livestock, and pets cannot come in contact with them. Remember, children and animals are curious and do not or cannot read labels. They do not know about or understand the hazards of pesticides.

Pesticides must always be stored in the original, labeled container with the label plainly visible. To avoid possible cross contamination, never store pesticides near human or animal food.

Stored containers should be periodically checked for corrosion, leaks, breaks, and tears. Faulty containers constitute a hazard and must be disposed of immediately. Always keep the lids and bungs tightened on containers.

Install an exhaust fan for ventilation in storage rooms to reduce concentrations of toxic fumes and to hold temperatures down. Do not permit anyone to sleep, smoke or eat in a room where pesticides are stored.

Guidelines for Storing Pesticides

- Plainly label the warehouse or storage room with the words "Danger" or "Poison", along with the familiar "Skull and Crossbones" sign.
- Post a list of chemicals being stored.
- Keep the storage room or building locked when not in actual use. Storage facilities should have limited access.
- Locate storage facilities as far as possible from other buildings and populated areas or away from normal pedestrian traffic within a dealer or applicator facility. Fence the area if necessary.
- When *large* quantities of pesticides are to be stored, install a sprinkler system.
- Storage areas should not have floor drains or existing floor drains should be sealed.
- All combustible materials should be kept away from steam lines or other heating devices.
- Glass containers of chemicals should not be placed in sunlight.
- Use fire proofing material, such as sheet rock, in the building.
- Inform the fire department and your physician, in writing, of the nature, quantities, and hazards of these compounds. Ask your local fire chief to inspect your facility at least once a year.
- Keep these individuals informed as to any changes in quantities, hazards, or nature of the contents of the facility.
- Make sure employees are familiar with the building's fire fighting equipment, alarms, and fire exits and the hazards of each pesticide product.
- Fire fighting equipment should be checked periodically and ready for use at all times.
- Request your physician or local hospital to have, on hand, the antidotes required in case of poisoning.

Pesticide Storage Life

Each pesticide formulation has a storage life. For example:

Chlorinated hydrocarbons are very stable and can be stored for a number of years with little or no chemical change. Organophosphorus pesticides, such as TEPP, Parathion, and others, have a relatively short storage life. Certain atmospheric conditions can bring about the degradation of these materials. Labels will warn of such limitations and specify steps for prevention of pesticide deterioration.

Liquid concentrates stored at low temperatures for prolonged periods of time may crystallize, separate or break down. The resultant material may be more or less toxic than the original, or may not perform as originally intended. Heat may cause vaporization of certain volatile compounds.

Some labels provide information on storage standards for the particular pesticide product. If storage information is not available locally, contact the company representative for recommendations.

► Transportation of Pesticides

The importance of prevention of pesticide spills cannot be over emphasized. Whenever a spill occurs during transportation the possibility of endangering the lives of others is increased. Spillage of hazardous pesticides in transport must be considered an emergency, requiring prompt cleanup, protection of human health, safe disposal of damaged containers or cargo, and possibly the disposal of the transport itself. Handling these emergencies requires assistance of technically trained DES personnel and possibly hiring an environmental consultant. Chemical spillage has caused poisonings among transportation personnel and others. Whenever a pesticide accident occurs, the welfare of persons directly involved and the general public must be considered.

Spillage may result from breakage of glass containers, puncturing of drums or cylinders, defective valves or fittings on tanks, and torn sacks. Transportation accidents many times result from the carelessness of shipping personnel loading transports and vehicle accidents. Interstate commerce laws require that all transports and hazardous cargoes be properly labeled. Pesticide products should never be transported with foods, drugs, toys, clothing, cosmetics or household items.

Guidelines for Transporting Pesticides

- ▶ All employees handling pesticides should be properly trained on potential hazards of loading and transporting pesticides.
- ▶ Read all container labels.
- ▶ Check for damage to and/or leaking of containers.
- ▶ Provide information on who to contact in case of an emergency.
- ▶ Hazardous cargo should be handled with extreme care.
- ▶ Develop a plan for handling spillage.
- ▶ Always tie down or otherwise ensure that containers remain upright and stable.

Safety Equipment for Transporting

Every vehicle transporting pesticides should carry:

- An emergency water supply for washing off corrosive and toxic materials,
- An approved respirator, goggles, or face shield to protect the eyes and face,
- Equipment for washing eyes, portable eyewash fountain or wash bottle, and
- Waterproof, impervious, complete outer clothing to wear when cleaning up or when exposed to corrosive or toxic materials. The best protection against most of the major hazards are impervious (neoprene) gloves, boots, hat and long sleeved, buttoned coats or suits. Manufacturers will provide specifications on special gear required for particular chemicals.

Safety Equipment in Loading Areas

Every permanent station where pesticides are loaded should have:

- An emergency deluge shower,
- An eyewash fountain, and
- Protective equipment for two or more persons.

Guidelines for Pesticide Transportation Accidents

When an accident involving a pesticide occurs, emergency personnel, such as highway patrol, sheriff, police or fire department personnel, are usually the first on the scene. These individuals should be familiar with the hazards of toxic materials and can provide necessary assistance. However, if they are not, they should notify the manufacturer to provide recommendations for clean-up, safety precautions, etc.

Clothing contaminated with chemicals should be removed immediately and exposed skin areas thoroughly washed. Individuals providing first aid should take special care not to become contaminated. Individuals receiving chemical burns or who are significantly contaminated with pesticides should be taken to the nearest physician or emergency hospital. Provide the physician or hospital personnel with a copy of the product label.

The cleanup crew must include at least two individuals. The crew must have all necessary protective equipment. To prevent harm to the public, especially children, pets, and the environment, leaking containers and contaminated cargo must be properly contained and disposed of in an approved site.

Container Specification

Each hazardous material, depending upon its characteristics, is required to be packaged in a specific type of container. Containers must meet standards established by the Department of Transportation (DOT). Routine inspections of container manufacturing plants are conducted by the DOT. Any failure of containers should be reported to the DOT. A specification number may be found on each container and reported to the DOT.

Placarding Transports

Vehicles transporting chemicals may need to be placarded, depending on the amount and class of hazardous material. Dealers and chemical companies are primarily responsible for making sure the vehicle hauling a hazardous material is properly placarded before transporting. These placards provide emergency personnel a quick reference as to the cargo being transported. Individuals reporting chemical transport accidents should always attempt to describe the placard on the vehicle to the proper authority. The Montana Highway Patrol, Motor Vehicle Inspection Bureau, is the primary enforcement agency and should be contacted for more detailed information about placarding regulations at **406-444-3300**.

Pesticide Applicator Transportation Accidents/Incidents

Pesticide applicators and dealers must be aware of the potential danger of traffic accidents while transporting pesticides. Types of problems which could occur are breakage of high pressure hoses or rupturing of spray tanks during a collision.

If an accident occurs, the first thing to do is to clear the area and decontaminate all parties involved, including yourself. Make sure all people, especially children, pets, and other animals are restricted from the area. Then call the following authorities:

- ✓ The Local County Sheriff's Dispatch Office or county DES officer
- ✓ The State Emergency Response Commission - **406-444-6911**
- ✓ The National Response Center - **800-424-8802**

Important Contacts

Montana Disaster and Emergency Services, hazardous material emergencies - **444-6911**

Montana Department of Environmental Quality: Solid Waste Disposal - **444-4400**; Water Protection Bureau - **444-3080**; Air and Waste Management Bureau (handling and disposal of hazardous waste) - **444-3490**.

Montana Highway Patrol, Motor Vehicle Inspection Bureau (placarding) - **444-3300**.

Montana Department of Agriculture for assistance and support - **444-2944**.

♦ Disposal of Pesticides and Their Containers

Proper disposal of pesticide containers and surplus pesticide is an essential operation for all applicators and dealers. Improper disposal may create serious health hazards or cause environmental contamination. Responsibility as an applicator or dealer continues until all excess pesticides and containers are disposed of correctly. Disposal includes, but is not limited to: *recycling, encapsulation, returning to manufacturer*, and other approved methods.

From the standpoint of public health, an "empty container" does not exist. Containers always retain residual amounts of pesticide. In the case of highly toxic pesticides, remaining residues may present a hazard to humans, especially children, pets, and livestock. All plastic or metal pesticide containers **must** be triple or power rinsed, prior to disposal and should be kept in a separate locked building,

room or enclosure used exclusively for storage of pesticides. To reduce the chance of container reuse and to allow for complete drainage it is a good practice to puncture pesticide containers after triple rinsing.

Most pesticide containers composed of plastic can be recycled through programs sponsored by pesticide dealers and distributors. The containers must be triple rinsed, drained dry, and have no visible residue. Labels and caps must also be removed. Pesticide containers, plastic and metal, that have been triple rinsed are considered solid waste and can be disposed in most sanitary landfills. Be sure to check with landfill operators to determine local policies for accepting pesticide containers.

Some pesticide labels have different requirements than the regulations of Montana for disposing of empty pesticide containers. The more restrictive requirement must be followed. The following is a summary of ARM 4.10.803 Rinsing Empty Pesticide Containers:

- ◆ All empty pesticide containers must be triple or power rinsed **except for:**
 - * aerosol containers,
 - * fiber drums with liners,
 - * paper, fiber, and plastic bags,
 - * containers designated by label for refilling,
 - * water soluble containers,
 - * compressed gas cylinders, and
 - * containers from retail pesticides labeled only for home, yard, and garden uses.
- ◆ Rinsing must occur within 48 hours of the time that container is rendered empty.
- ◆ Use rinsate as diluent in pesticide applications.
- ◆ Do not reuse pesticide containers.

Triple Rinse Method

The minimum amount of rinse material for each rinse will be based upon the container size as specified below:

| Container Size | Solution Required |
|-----------------------|-------------------------------|
| less than 5 gallons | 1/4 of the container's volume |
| 5 gallons or more | 1/5 of the container's volume |

Examples:

| | |
|---------------------|-------------------------------|
| 1 gallon container | add 1 quart rinse solution |
| 5 gallon container | add 1 gallon rinse solution |
| 30 gallon container | add 6 gallons rinse solution |
| 50 gallon container | add 10 gallons rinse solution |

- ◆ Secure lid on container and agitate to ensure all inside surfaces are rinsed.
- ◆ Pour the rinsate from the container into a spray tank and allow it to drain for 30 seconds.
- ◆ Rinse two more times or more, until no visible residues are present.

Power Rinse Method

- ◆ The minimum amount of rinse material must be $\frac{1}{2}$ the volume of the container.
- ◆ The minimum pressure of the rinse material needs to be 15 pounds per square inch.
- ◆ The nozzle must be capable of rinsing all inner surfaces of the pesticide container.
- ◆ Rinsing needs to continue until no visible residues are present and allow the container to drain for 30 seconds.

Other disposal tips for pesticide containers:

- ➥ To obtain maximum drainage of the pesticide material into a tank, puncture the head of the metal or plastic container.
- ➥ After rinsing has been completed, dispose of containers in a sanitary landfill, recycle or recondition.
- ➥ Burning or incineration of pesticide containers is prohibited except when approved by DEQ.

Disposal of Large Volumes of Pesticides

Applicators or dealers desiring to dispose of larger volumes of improperly labeled, old or unusable pesticides should contact the Montana Department of Agriculture (MDA) - Pesticide Disposal Program at 406/444-5400 or DEQ, Air and Waste Management Bureau at 406/444-3490. The DEQ will give technical assistance and recommendations for proper disposal to prevent environmental and public health accidents.

CHAPTER VIII

TOXICOLOGY OF PESTICIDES

Toxicology is the study of harmful effects of a chemical on living things. In the quest to determine how harmful a chemical is on a living organism, information is also obtained on the chemical's degree of safeness. When describing the degree of harmfulness or safeness of a chemical, the terms "toxic" and "toxicity" are commonly used. The toxicity of chemicals is always qualified by the type of laboratory test performed, the quantity causing effects on the biological organisms, the biological organism tested, and other conditions of the study.

The toxicity of a chemical is an inherent quality of the chemical and cannot be changed. However, the effect of any compound on living organisms is dependent on the dosage received. The dose makes the poison. This is generally considered the most important principle in toxicology. A sufficiently large dose of a material that is generally considered nontoxic will be fatal (i.e., water, salt). Exposure to a sufficiently small dose of even the most toxic compounds may be without harm (a small dose of strychnine was commonly used medicinally as a stimulant).

Information used to determine the toxicity of a pesticide can include test data from animals, such as rats, rabbits and monkeys; "in vitro" (test tube) studies of animal or human tissues, clinical reports of human or animal poisonings, and human laboratory or population (epidemiological) studies.

People sometimes question the use of animals to predict effects in humans because animals and humans are so different, but animal tests of toxicity can be very useful. Even though humans and animals look and act differently, their organs, cells, and important molecules in their bodies are very similar. For example, insulin derived from pigs is nearly identical to human insulin and works very well in human diabetics. Pesticides are toxic because they affect organ function or important molecules in the body, and this is where humans and animals are most similar. Thus, finding a toxic effect in an animal is a strong signal that a similar toxic effect will likely occur in humans.

Pesticides are not risk-free. The reason that EPA allows the use of products with the potential to cause toxicity is that, **When Used According To Label Instructions**, the risks of the pesticide are outweighed by its benefits. Reading and following labels is the best way to ensure that health effects do not occur. If the EPA learns that applicators repeatedly fail to use a pesticide in accordance with the label, it will find other ways to reduce risks of that product, including restricting its use or even an outright ban.

♦ Tests for Determining Toxicity

The types of toxicity tests which EPA requires for pesticide registration include: acute (short term) oral, dermal and inhalation toxicity; acute delayed neurotoxicity; eye and dermal irritation; dermal allergic sensitization; subchronic (longer term) oral, dermal, inhalation and neurotoxicity; chronic toxicity, oncogenicity (cancer), teratogenicity (birth defects), reproductive effects and mutagenicity.

EPA also requires information on the toxic effects of a pesticide on fish and wildlife. The following are the basic types of toxicity tests:

- ✓ **Acute** tests are conducted by administering a single dose of chemical orally, dermally, subcutaneously, or via the respiratory route, and observing the effects on test animals over a short time period of 1 to 2 weeks.
- ✓ Prolonged or **chronic** tests administer chemicals over a period of three months or as long as one or two years.
- ✓ Specific tests are performed to reveal additional adverse characteristics of a chemical. Adverse effects of a special nature include:
 - * **Synergism** (Potentiation) -- The effect of a combination of two chemicals is greater than the sum of their individual effects. A contrasting phenomenon occurs when the toxicity of a pesticide may decrease when administered to a test animal pre-treated with a different pesticide. This phenomenon is called **antagonism**.
 - * **Teratogenesis** -- The effect of a pesticide administered to a test animal causes birth defects or abnormalities in developing young (including the fetus).
 - * **Carcinogenesis** -- The effect of a pesticide administered to a test animal produces cancerous growths.
 - * **Mutagenesis** -- The effect of an administered pesticide on a test animal causes genetic damage resulting in hereditary changes.

Toxicity tests are not confined to animals. Toxicity evaluations are also made on plants (phytotoxicity). For example, sulfur, oils, and numerous other chemicals may be toxic to plants. For the purposes of this chapter, this discussion will relate to animal toxicity only.

Toxicity values are expressed in a number of ways depending upon the method of administration and the effect the researcher is interested in. They may be expressed as:

Acute oral LD₅₀ - milligrams of the substance per kilogram (mg/kg) of body weight of the test animal, administered through the mouth.

Acute dermal LD₅₀ - milligrams of the substance per kilogram (mg/kg) of body weight of the test animal, administered to the skin.

Inhalation data - either micrograms of dust or mist per liter of air (ug/l) or parts per million by volume of gas or vapor (ppm). One microgram equals one millionth of a gram.

Skin sensitivity - the amount of substance applied per square centimeter of skin (mg/cm²) causing little or no, moderate, or severe skin irritation.

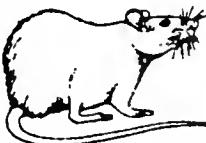
LD means lethal (fatal) dose, and **LD₅₀** means the dose that will kill 50% of a population of test animals. **LC** means lethal concentration and **LC₅₀** means the concentration that will kill 50% of the test animals. In some cases, the lethal dose (LD) or lethal concentration (LC) may be expressed as **LD₉₀** or **LC₁₀₀**; the dose required to kill 90% of the test animals and the concentration required to kill 100% of the test animals, respectively.

Acute oral refers to a single dose taken by mouth or orally.

Acute dermal refers to a single dose applied directly to the skin (skin absorption).

Inhalation refers to exposure through breathing or inhaling a predetermined contaminated atmosphere.

Acute toxicity values of one compound are more meaningful when compared with another chemical and with similar test animals and laboratory tests. The following chart is comparing two organophosphate insecticides, methyl parathion and malathion, but when compared to other pesticides, malathion may be more toxic.

| Pesticides | Methyl Parathion | Malathion |
|--|---|---|
| Toxicity Value for rats  | Acute Oral LD ₅₀ 6 mg/kg | Acute Oral LD ₅₀ 5500 mg/kg |
| | Acute Dermal LD ₅₀ 45 mg/kg | Acute Dermal LD ₅₀ 2000 mg/kg |
| Toxicity | High Toxicity | Low Toxicity |

Acute toxicity can be a function of the amount of toxicant received, the route of administration, and the type of animal tested. A host of factors may alter the "predicted" effect of a chemical on a living organism. These factors are:

- * the physical and chemical properties of the pesticide or its formulation,
- * the pesticide mode of action (e.g. how the pesticide causes tissue damage or poisoning),
- * age, sex, and race of the test animal,
- * size and weight of the test animal,
- * condition of health of the test animal,
- * genetic characteristics of the test animal,
- * individual susceptibility,
- * the hazard confronting the applicator,
- * nutrition, and
- * temperature and environmental factors.

Chronic toxicity results from prolonged, repeated, or continuous exposure to a chemical. This is usually the result of exposure to levels lower than that necessary to cause acute toxicity and often demonstrates a delayed response. Public concern toward pesticides generally focuses on possible chronic toxicity. Sublethal poisoning or exposure may be expressed by any of the following:

- * skin/eye irritation,
- * nervous system disorders,
- * reproductive system disorders,
- * damage to other organ systems (liver, kidney, lungs, etc.),
- * birth defects,
- * mutations, and
- * cancer.

One view suggests that one exposure to a carcinogenic substance is capable of causing cancer. Currently the EPA follows this assumption when considering carcinogenic potential for most pesticides. This is a conservative approach meant to be protective of public health. For example, it is thought that children's rapid growth and development may make them more susceptible to carcinogenic chemicals. Another view is that there is a threshold or a minimum dose for any chemical and the effect that it may cause. A reasoning cited to support this is that people are constantly exposed to carcinogens from natural sources in foods. These natural carcinogens exist in amounts and potencies greater than the pesticide residues that may be found in food consumed by humans and that there is no evidence that cancer rates have changed over historic levels. The counter argument is that humans have evolved tolerances to naturally present carcinogens but not the synthetic chemicals developed during the last 50 years. It is generally thought that animals, including humans, are capable of handling small amounts of a wide variety of foreign chemicals. Only when natural defense mechanisms are overwhelmed by taking too much at one time, or too much too often, are effects observed. This debate will continue and answers will only come with continued scientific study.

Skin irritation (dermal exposure) may be in the form of chemical burns, dermatitis or eczema. Skin irritation is also characteristic of some highly toxic pesticides. However, it is not observed frequently because users generally protect themselves from skin contact with these chemicals. Dermal toxicity data for chemicals used in plant disease control (fungicides), as well as herbicides and plant growth regulators, are limited. A number of these compounds are of low mammalian toxicity or are not readily absorbed through the skin. Some animal tests and human experiences have shown several of these chemicals to be irritating to the skin and eyes and in severe cases may be incapacitating.

► Health Hazards of Pesticides

It is common practice to depend exclusively on acute toxicity values when evaluating the effect of a chemical on humans or other animals. Judgments regarding chemical safety based upon this single consideration can be short-sighted and often erroneous. Users of pesticides should be additionally concerned with the hazard associated with the **exposure** to the chemical and not exclusively the **toxicity** of the material itself. These two terms are not synonymous and both must be considered when determining safety precautions.

Toxicity is the inherent capacity of a substance to produce injury or death. **Hazard** is a function of two primary variables, potency (quantity of a chemical needed to induce harm) and exposure and is the probability that injury will result from the use of a substance in a given formulation, quantity or application method. A compound may be extremely toxic but present little hazard to the applicator or others when used:

- ◆ in a very dilute formulation,
- ◆ in a formulation that is not readily absorbed through the skin or readily inhaled,
- ◆ only occasionally and under conditions to which humans or other organisms are not exposed, or
- ◆ only by experienced applicators who are properly trained and equipped to handle the chemical safely.

A chemical may exhibit relatively low toxicity but present an increased hazard because:

- ◆ it is normally used in the concentrated form.
- ◆ it may be readily absorbed or inhaled.
- ◆ it is used frequently, increasing chances of accidents or spills.
- ◆ it is stored in a manner that increases chances of spillage or access to unauthorized people.

With most pesticides, regardless of their toxicity values, formulation, or dilution, a health hazard exists when:

- ✓ appropriate protective clothing is not used,
- ✓ good personal hygiene is not practiced,
- ✓ chemicals are improperly stored, transported, or disposed,
- ✓ applicators are unaware of the greatest exposure hazard in their operation, and
- ✓ an applicator applies a chemical improperly mixed, or applies it at the wrong rate.

Endocrine Disrupters - The human endocrine system is composed of several glands including the adrenal, thyroid and pituitary glands which produce internal secretions (hormones) which are carried by the bloodstream to other organs and parts of the body and function in the regulation and control of the body systems. There is a growing body of scientific research that indicate that some industrial chemicals and pesticides may interfere with the normal functioning of human and wildlife endocrine systems. That is, endocrine disrupters may interfere with the synthesis, secretion, transport, binding, function or elimination of natural hormones which in turn may affect normal reproduction, development and behavior. It is thought that these effects may occur from minute exposures of these chemicals.

Inert Ingredients - Pesticide formulations contain "inert" ingredients which, while not pesticidally active, may have toxicity. Moreover, symptoms may not appear immediately after exposure, but may be delayed by hours or even days. Applicators should be alert to any symptoms that appear work-related, including changes in behavior.

The relationship between toxicity and hazard can be illustrated by the compound aspirin, which is commonly used as a standard for comparing safety of pesticides or other chemicals. Aspirin has an LD₅₀ of 1,200 mg/kg and is considered slightly toxic and believed by some people to be harmless. Yet, aspirin is responsible for more than 10 percent of all poisonings among children under five years of age. In the home, in non-child-proof bottles, on an open shelf, aspirin is an extreme hazard. The difference between a poison and a remedy is often only the dose.

♦ **Acute Pesticide Effects on Humans and Recognition of their Signs & Symptoms**

The particular way a pesticide affects a human (or any living thing) is referred to as **Mode of Action**. Even though we may not know how a pesticide poisons the body in all cases, the signs and symptoms resulting from such poisonings may be well known. Early signs and symptoms serve as warnings by the body in response to pesticide exposure. These warnings should be recognized by those using pesticides. The signs and symptoms of poisoning may be quite variable among individuals and may depend upon whether the exposure is to a large quantity of toxicant (e.g. splash or spill) over a short period of time or to smaller quantities over an extended period of time.

Any experience of signs and symptoms associated with a recent history of pesticide exposure should be reported to your physician. You should advise him of the signs and symptoms, the pesticide utilized, method of application, amount and time of exposure and the conditions of exposure. A complete label must be provided to your physician.

Poisons work by changing the speed of different body functions, such as increasing the heart rate or sweating, or decreasing to the point of stopping, like breathing. For example, people poisoned by an organophosphate insecticide, such as parathion, may experience increased sweating. Increased sweating caused by parathion poisoning begins by the biochemical inactivation of an enzyme. This biochemical change leads to a cellular change, in this case an increase in nerve activity. The cellular change is then responsible for physiological changes, which are the symptoms of poisoning that are seen or felt in particular organ systems, in this case, the sweat glands.

Organophosphate insecticides are pesticides for which the toxicological mechanism is fairly well understood. Organophosphate insecticides attach themselves to a chemical found in the blood, the nervous system and the junction between the nerves and the various other tissues of animals. This chemical is called cholinesterase and is essential to the normal functioning of the nervous system. During normal muscle function, acetylcholine is released by a nerve impulse and it acts on that muscle to produce the contractile response. Cholinesterase is then released and by breaking down acetylcholine, helps restore the muscle to its normal resting state. When an organophosphate insecticide is present in the system, it blocks the function of cholinesterase by attaching to it and is referred to as a cholinesterase inhibition. This "tie-up" of cholinesterase by the insecticide keeps the muscle in an active (contracted) state and is characterized by muscle twitching and weakness (tremors and fibrillations, respectively) and may cause seizures and convulsions, which are simply uncontrolled, violent muscle actions.

Phenoxy Herbicides, such as 2,4-D and MCPA, cause skin irritation or a burning sensation when inhaled. Dizziness or chest pain may result from prolonged inhalation. When large quantities of the pesticide are absorbed, muscle twitching, muscle tenderness, and muscle stiffness may occur. Several phenoxy herbicides have been associated with an increased risk of non-Hodgkins lymphoma in epidemiological studies, but at this time, EPA does not consider them to be carcinogenic in humans.

The basic progression of effects from biochemical to cellular to physiological occurs in most all cases of poisoning. Depending on the specific biochemical mechanism of action, a poison may have very widespread effects throughout the body, or may cause a very limited change in physiological functioning in a particular region or organ. Parathion causes a very simple inactivation of an enzyme which is involved in communication between nerves. The enzyme which parathion inactivates, however, is very widespread in the body, and thus many varied effects on many body systems are seen besides sweating.

It is often difficult to tie specific poisoning signs and symptoms to a particular pesticide or even a class of pesticides. Poisoning symptoms manifested by a poisoning victim may be similar even among pesticides with greatly different modes of action. In general, the following signs and symptoms may be experienced by a poisoning victim.

- ⌚ **Early** symptoms may include headache, giddiness, nervousness, blurred vision, weakness, nausea, cramps, and diarrhea.
- ⌚ **Later** symptoms may include heavy sweating, constricted pupils, tearing, salivation, vomiting, bluing of skin and muscle twitching.
- ⌚ **Advanced** symptoms may include convulsions, coma, loss of reflexes, and inability to control bowels or bladder.

Illness as a result of pesticide exposure maybe delayed several hours because of rates of adsorption and mode of action. Symptoms may not become apparent until after exposure to the pesticide has stopped. This may result in the victim not relating his illness with the use of a pesticide. Symptoms can be confused with influenza (flu), heat prostration, alcohol intoxication, exhaustion, hypoglycemia (low blood sugar), asthma, gastroenteritis, pneumonia, and brain hemorrhage. This can cause problems if the symptoms are ignored or misdiagnosed as something other than pesticides and result in mistreatment.

Table 8.1 - Toxicity Classes.

| LD ₅₀ Toxicity Class | LD ₅₀ Oral Dose Rate mg/kg | LD ₅₀ Dermal Dose Rabbits mg/kg | Oral Dose Adult humans |
|---------------------------------|---------------------------------------|--|------------------------|
| Extremely toxic | 1 mg or less | 20mg or less | a taste |
| Highly toxic | 1 - 50 mg | 20 - 200 mg | a pinch - 1 tsp. |
| Moderately toxic | 50 - 500 mg | 200 - 1000 mg | a 1sp. - 2 tsp. |
| Slightly toxic | 500 - 5000 mg | 1000 - 2000 mg | 1 oz. - 1 pt. |
| Practically nontoxic | 5000 - 15,000 mg | 2000 - 20,000 mg | 1 pt. - 1 qt |
| Relatively harmless | 15,000 mg | 20,000 mg | 1 qt |

► How Pesticides Enter the Body (Exposure)

Chemicals may enter the body by the following routes:

Contact and absorption of the material by the skin referred to as **dermal exposure**. Breathing the fumes, vapors or dusts, referred to as **inhalation exposure**. Eating or drinking the material, referred to as **oral exposure**. Direct entrance or absorption through cuts, abrasions, or burns, referred to as **wound exposure**.

Dermal Route

Absorption through the skin is the most important route of entry of pesticides into the body, especially when liquid sprays and emulsifiable concentrate formulations are involved. Most of the pesticides to which the body is subjected during typical exposure situations, especially to applicators of liquid sprays, is deposited on the skin. Dermal exposure is undoubtedly responsible for most poisonings occurring in the field.

The greatest dermal penetration for most pesticides on humans occurs in the genital area, where up to a 100% absorption may occur. The head and neck are areas of greater absorption than arms and hands. Pesticides can readily absorb through the skin in areas where blood vessels are close to the skin surface and have an abundance of sweat glands. The mucus membranes of the eyes, ears, nose and mouth area also areas where a high degree of absorption occurs. Exposure in these areas can occur through drift of fine pesticide mists or dusts or by rubbing these areas with contaminated hands.

In general, wettable powders, dusts, and granular pesticides are not as readily absorbed through the skin and other body tissues as are liquid formulations, such as emulsifiable concentrates, containing a relatively high percentage of toxicant in a solvent. The implications of these factors and relationships emphasize a need for providing protection of critical areas receiving high exposure. Figure 1, on the next page, presents information on percent absorbed by specific body parts of a typical liquid pesticide formulation.

Respiratory Route

Absorption of a chemical by the lungs is rapid and very complete. Pesticide absorption through the lungs is of increased importance where toxic dusts and vapors or very small droplets are prevalent or where application is in confined spaces. Respiratory hazards are greater when low volume equipment is used, as opposed to conventional application equipment producing large droplets. Pesticides inhaled in sufficient quantities may cause serious damage or irritation to nose, throat, and lung tissues.

Oral Route

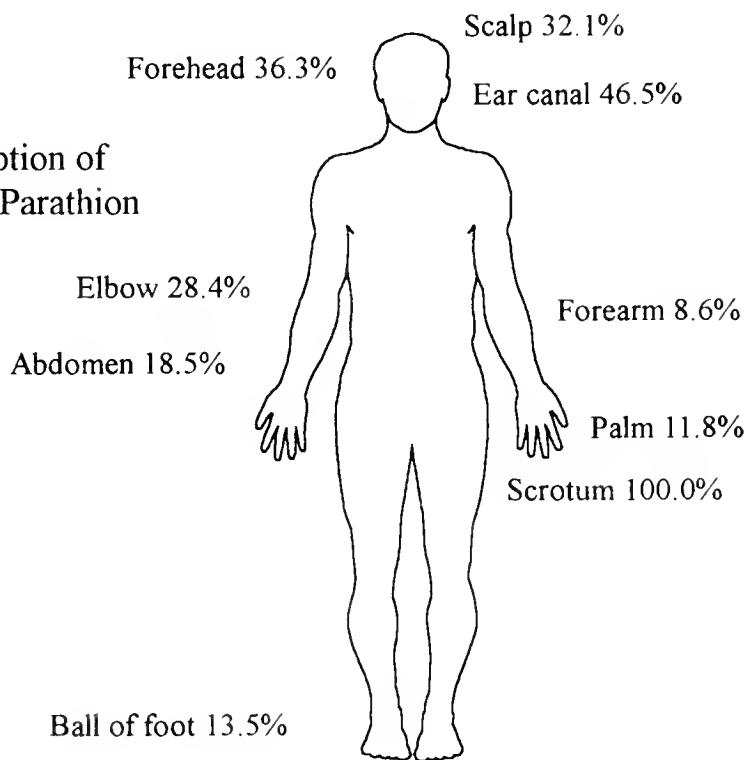
Pesticides taken through the mouth in amounts sufficient to cause serious injury or death occur by accident or by intent to do self-inflicted injury. The most frequent cases of accidental ingestion are those in which chemicals have been put in unlabeled bottles of food containers or stored where children or irresponsible adults may consume them.

The most serious oral exposure for a pesticide applicator may be caused by splashing of liquid concentrate into the mouth while pouring and measuring pesticides, wiping the mouth with contaminated arms, by attempting to blow out clogged spray nozzles with the mouth, or by eating, smoking or drinking while hands are contaminated.

Wound, Cuts, Abrasions, and Burns Route

Any break in the skin may allow a direct route of entry into the blood stream. Even the removal of the outer layer of dead cells of the skin by scraping or scratching may increase the potential for skin absorption. Burns, dermatitis, and eczema resulting from chemical exposure may also enhance the absorption of chemical through the skin.

FIGURE 1



CHAPTER IX

PROTECTIVE PESTICIDE EQUIPMENT

The best insurance against poisoning by pesticides is to protect the routes by which these chemicals enter the body: oral, dermal, respiratory, and through cuts and abrasions. Good protection requires the routine use of respiratory protective devices, dermal protective garments, and sound practices of personal cleanliness.

There is a wide variety of protective equipment available, varying in the quality of protection afforded to the pesticide user. In any application, the minimum amount of protection to be worn, by law, is stated on the pesticide label. The proper selection and use of this equipment largely depends upon the applicator's judgment regarding toxicity, hazards, types of spray equipment employed, and type of work environment.

Prevent pesticide exposure to your body by selecting adequate personal protective equipment (PPE). Personal protective equipment is defined as apparel and devices worn to protect the body from contact with pesticides or pesticide residues, including:

- ◆ coveralls
- ◆ chemical resistant suits, gloves, footwear, aprons, and headgear
- ◆ protective eyewear
- ◆ respirators

This also includes clothing that covers the arms, legs, torso, and head and prevents pesticide dust or liquid from contacting the skin. Gloves and boots are used to protect hands and feet, while helmets, hoods, or wide-brimmed hats prevent exposure to the head and neck. Face masks or goggles protect the eyes. Avoid breathing dusts, mists, or vapors by selecting an appropriate respirator.

Always anticipate accidents and be sure your body is adequately protected under any possible circumstance. For example, when handling pressurized fumigants, a hose from the tank might rupture, causing the hose to violently whip around while releasing large quantities of fumigant. Therefore, when using fumigants from a cylinder, wear goggles or a face shield to protect your eyes and a self-contained respirator for safe breathing under emergency conditions.

► Wovens, Nonwovens and Coated/Laminated Suits

The most common route for pesticides to enter and poison the body is through the skin. There may be no immediate effects, but the long-term health effects can be serious. One of the best defenses against contamination if you handle pesticides is to always wear adequate protective clothing. But knowing which fabrics and style of clothing to choose isn't that simple.

Protective clothing is available in numerous styles and is made of many different materials. Among the fabrics commonly used for protection against pesticides are wovens, nonwovens, and coated/laminated fabrics.

Wovens

These are constructed of natural or synthetic yarns that are woven or knitted together to form a fabric. Some examples of woven fabrics are blue jeans, flannel shirts and cotton coveralls. Cotton or cotton/polyester blends offer the best protection of the woven fabrics. Heavier weaves such as cotton duck or denim are often good choices.

WARNING:

Never wear materials made from 100% polyester, nylon or acrylic when working with pesticides. They do not provide adequate protection.

Woven fabrics are primarily worn for protection against low-toxicity solid (dry) pesticides such as granules, dusts and powders. Although EPA allows woven coveralls to be worn to meet the coverall requirement on the pesticide label, woven fabrics are not the preferred barrier since the

weave has a tendency to “open up” or “stretch,” allowing fine particulates or liquids to pass through the clothing. Woven or knit fabrics actually absorb liquid chemicals and hold them next to the skin. Garments made from woven fabrics are considered “reusable” since they can be cleaned or decontaminated. Woven fabrics are not recommended when there is a chance of exposure from highly toxic liquid pesticides or fumigants.

Nonwovens

Nonwovens are made of natural or synthetic materials that are bonded together with heat or pressure. Nonwovens protect against most solid pesticides, such as dusts, powders and granules. They also offer protection against accidental splashes and low pressure sprays of low-toxicity liquid pesticides. It is not recommended that uncoated nonwovens be worn for prolonged exposure to high-toxicity liquid pesticides unless they are coated or laminated. *Example:* some so-called white “disposables” made from polypropylene will protect you against nonhazardous materials such as dirt and grease, but they offer no chemical protection. Other clothing is laminated or coated with a special film that gives it resistance to a wide variety of chemical hazards.

Breathable Nonwovens are made from liquid-proof microporous membranes sandwiched between two layers of the nonwoven material or a microporous film laminated to a nonwoven fabric. These are a good choice in hot climates. The breathable nature of the material allows water vapor from perspiration to pass through the clothing, keeping the wearer cooler and more comfortable than the applicator would be in non-breathable PPE. The degree of dry and liquid barrier protection can vary greatly depending on the composition of the microporous film and nonwoven fabric. Some breathable fabrics are made from “filter materials” which keep out small particles, but are NOT waterproof.

WARNING:

Although some of these fabrics are waterproof, they are not vapor tight. If these fabrics are to be used for protection from pesticides over an extended period of time, consideration should be given to the effect, if any, of vapor on the skin.

These should not be used with liquid pesticides. Check with your supplier to make sure you have the right clothing for your label needs.

Coated or Laminated Nonwovens are made by thermally bonding or adhesively attaching a

barrier film or polymer to the outer surface of a nonwoven fabric. The result is a barrier material that provides the highest level of protection against pesticides for limited use apparel.

Coated/laminated suits

Reusable coated or laminated suits are often referred to as "rubber" suits because the fabrics feel like rubber. These are made of a base material, such as nylon, that is coated with a chemical barrier, such as polyvinyl chloride (PVC), rubber, neoprene or nitrile. Most industrial grade rainwear can be used for chemical protection. These provide similar protection as the coated nonwovens, but are very heavy and not breathable.

WARNING:

Coated/laminated suits are often confused with inexpensive rainsuits. Do not use thin rainsuits for chemical protection because they could tear and may not be an adequate chemical barrier. A thickness of at least 20 mil. is recommended. Also, do not use rainsuits made out of urethane materials. They will not protect you against chemicals.

Several styles of rainsuits have cotton liners or cotton corduroy collars. Cotton is absorbent and can hold in pesticides. Do not use them. The following sections give more information about wovens, nonwovens and coated/laminated suits.

WOVEN FABRICS

Design: Generally one-piece coveralls, overalls, or suits, long-sleeved shirts, long pants

Examples: Fisher Stripe® coveralls, 100% cotton coveralls, 65% cotton 35% polyester blends and overalls

Application: Mixer, loader, applicator protection against dry particulate pesticides (powders, dusts and granules). Limited splash/spray protection from liquid pesticides.

| STRENGTHS: | WEAKNESSES: |
|---|--|
| <ul style="list-style-type: none">• Reusable• Breathable• Light to medium weight• High worker acceptance• Can be washed and decontaminated numerous times | <ul style="list-style-type: none">• Not liquid proof• Offer little to no protection against highly toxic pesticides (liquid/solid)• Must be decontaminated after every use• Retain pesticide residues in fabric, even after decontamination, which can contaminate other clothing |

NONWOVEN FABRICS

Uncoated Nonwovens

Design: One-piece and two-piece suits/coveralls, aprons, hooded clothing, pants, long-sleeved shirts, hats, and shoe coverings

Examples: Tyvek®, Comfort-Gard®, KLEENGUARD LP®

Application: Mixer, loader, applicator protection against dry particulates (powders, dusts, and granules). Limited splash/spray protection from liquid pesticides.

| STRENGTHS: | WEAKNESSES: |
|---|---|
| <ul style="list-style-type: none">• Breathable (depending on fabric)• Lightweight• Numerous styles available• Some offer splash protection from liquid pesticides• Limited use eliminates laundry cross contamination | <ul style="list-style-type: none">• Limited protection against high-toxicity liquid pesticides• Nonbreathables can be quite hot to wear• Limited use- most manufacturers recommend no more than 8 hours of use• Local disposal regulations may pose problems |

Coated Nonwovens

Design: One-piece and two-piece suits/coveralls, aprons, hooded clothing, pants, long-sleeved shirts, hats, and shoe coverings.

WARNING:

Nonwoven fabrics are not flame resistant and should not be used around heat, flame, sparks, or in potentially flammable or explosive environments.

Examples: Tyvek QC®, Saranex 23 P®

Application: Mixer, loader, applicator protection against liquid and dry pesticides.

| STRENGTHS: | WEAKNESSES: |
|--|--|
| <ul style="list-style-type: none">• Numerous styles available• Good protection against most liquid pesticides• Splash/spray protection | <ul style="list-style-type: none">• Some materials are costly• Uncomfortable in hot and humid climates• Limited use- most manufacturers recommend no more than 8 hours of use• Local disposal regulations may pose problems |

COATED/LAMINATED SUITS

Design: Generally one-piece and two-piece coveralls or suits, hats, jackets, pants

Examples: PVC coveralls, nitrile suits, TRI-WEAVE®, neoprene suits, numerous industrial grade rainwear styles made of these materials

Application: Mixer, loader, applicator protection against liquid and dry pesticides

| STRENGTHS: | WEAKNESSES: |
|--|--|
| <ul style="list-style-type: none">● Durable● Reusable● Good protection against liquid pesticides | <ul style="list-style-type: none">● Heavy material● Must be decontaminated after every use● Uncomfortable in hot and humid climates● Often lined with cotton or constructed with fabric collars, which makes them impossible to decontaminate |

► Protective Clothing Characteristics

The following table will help comparing fabric characteristics and choose the appropriate protective clothing for a specific pesticide application.

| MATERIAL | PARTICULATE PROTECTION (TOXICITY CLASS) | LIQUID-PROOF | L I Q U I D C H E M I C A L PROTECTION | SPRAY/SPLASH (TOXICITY CLASS) | BREATHABLE |
|---|---|--------------|--|-------------------------------|------------|
| WOVEN Wall's Fisher Stripe® | Yes (III) | No | No | No | Yes |
| NONWOVEN UN-COATED Tyvek® (white and blue) | Yes (I) | No | No | Yes (III) | No |
| KLEENGUARD LP® | Yes (I) | No | No | Yes (III) | Yes |
| Comfort-Gard® 150 (white and tan) | Yes (I) | No | No | Yes (II) | Yes |
| Comfort-Gard® 200 | Yes (I) | Yes | Yes | Yes (I) | Yes |
| NONWOVEN COATED Tyvek QC® Sewn Seams Sealed Seams | Yes (I) | No | Yes | Yes (I) | No |
| Saranex 23 P® (sealed seams) | Yes (I) | Yes | Yes | Yes (I) | No |
| COATED/ LAMINATED SUITS TRI-WEAVE® (vinyl coated) | Yes (I) | Yes | Yes | Yes (I) | No |
| Nitrile Coated | Yes (I) | Yes | Yes | Yes (I) | No |
| PVC | Yes (I) | Yes | Yes | Yes (I) | No |
| Neoprene Coated | Yes (I) | Yes | Yes | Yes (I) | No |

Different styles of PPE may be selected based on personal preference and the type of work performed. Common styles include coveralls, bib overalls, jackets, and aprons. Protective clothing is made from several types of materials, providing choices in chemical resistance, weight and strength

of the fabric, fabric resistance to ripping and puncturing, response to temperature extremes, comfort, ability to be cleaned, and durability. No single material provides everything, so base your selection on your most important need, protection from pesticide exposure.

One-piece suits

One-piece suits reduce the risk of pesticide contamination by providing a single continuous covering over the entire length of the body. One-piece suits have fewer seams and gaps than two-piece suits—so there is less chance of contamination. However, one-piece suits may be slightly more constrictive than two-piece suits because there is no gap around the midsection. Consider buying one or two sizes larger to allow greater movement and reduce heat stress.

Two-piece suits

A benefit of a two-piece suit is that it allows more freedom of movement than a one-piece suit. However, two-piece suits have more seams and gaps than one-piece suits, which means there are more routes for pesticides to get inside the clothing. Two-piece suits are sometimes cooler than one-piece suits because of the extra gaps that act as vents, allowing air to get in and out. But be careful not to let pesticides get between the jacket and the pants, since pesticides are sometimes suspended as mists in the air.

Impermeable Cloth

This clothing should be used when there is a potential for spill of concentrated materials, heavy drift which may saturate clothing, or prolonged exposure to light drift. Heavy gauge material should be selected rather than light if there is a potential for tearing the clothing. This clothing is often made of rubber, neoprene, or polyvinyl chloride (PVC) bonded to some type of woven fabric.

Heavy Grade Cloth One-piece

These one-piece suits (coveralls) should be made of heavy grade cotton with a tight weave. Cotton coveralls afford a reasonable degree of protection in most spray operations. They should be changed when noticeably wet and washed after each day's use in a strong detergent wash. Coveralls should not be worn where spills of concentrated pesticide may occur.

Paper Jackets and Paper Coveralls

These coveralls have been tested and are suitable for use only under conditions where heavy wetting does not occur and under conditions not conducive to tearing of the material.

Gloves

Unlined, impermeable gloves covering the forearm provide the best protection. Gloves providing this type of protection can be composed of nitrile, neoprene, PVC (polyvinyl chloride) or butyl. Cotton, leather or other absorbent gloves should not be used when working with pesticides. Also, materials such as leather, cannot be effectively decontaminated by washing. Heavy weight gloves, although more durable, do not allow suitable freedom of movement, especially finger dexterity. An applicator may be more inclined to remove this type of glove when cleaning nozzles and adjusting equipment. Additionally, heavy weight gloves are more difficult to turn inside out to clean. Cloth lining can

become contaminated and is not easily cleaned. Do not use cloth lined gloves. On the other hand, light weight gloves wear out easily. If light weight gloves are used, they should be frequently checked for pinholes and breaks. Gloves should be selected which are durable and provide a reasonable amount of finger dexterity.

Head and Neck Covering

Several types of head gear are available to protect the head, neck, and hair from pesticide drift. Head gear should be impermeable (waterproof), easily washed, capable of withstanding harsh detergents, and should provide protection to the ears and neck areas from downward drift. Broad brimmed, waterproof rainhats, waterproof hoods or certain types of tight fitting helmets are recommended.

Under no conditions should old felt, leather or similar type hat be used in lieu of waterproof hats. They absorb pesticides, especially in the sweat band, and thereby provide continuous skin contact.

In some instances, such as spraying hanging plants or spraying orchards, the pesticide label may require protection from possible overhead exposure. A hood will protect the head and neck. A hat, on the other hand, may not always protect the back of the neck. Hoods are available as separates or may be attached to jackets or coveralls. Attached hoods offer better neck protection because they have no openings for pesticides to seep in.

Protective Eyewear

Good, effective non-fogging goggles are readily available and should be worn when there is a chance of chemical contact with the eye. Safety glasses increase the amount of facial protection when used with half mask respirators.

NOTE:

All protective clothing and clothes worn under them should be scrupulously cleaned in hot, soapy water after each day's use. Wearing contaminated clothing allows the pesticide to penetrate the clothing and come in contact with the skin. This takes on added importance on hot days, when the rate of skin absorption increases. Applicators in some cases do not put on protective clothing until they begin to feel the drift. By this time, there may be considerable chemical deposited upon the skin or regular clothing. By putting on impermeable clothing over already contaminated clothing or skin, conditions which tend to increase skin absorption may be created.

Approved Respiratory Protective Equipment

Only those respiratory protective devices designed, approved, or accepted against the particular hazard should be used for respiratory protection. For protection from pesticides, the use of respirators should be limited to those approved by the U.S. Department of the Interior, Mining Enforcement and the Safety Administration (MESA) of the U.S. Department of Health, Education and Welfare, Center for Disease Control, National Institute for Occupation

Safety and Health (NIOSH). *The pesticide label will provide the number of an approved respirator to purchase when using the product.*

◆ Classification, Description & Limitations of Pesticide Respiratory Protection Devices

There are two basic types of respiratory devices for protection against pesticides:

- cartridge respirators and
- supplied air respirators.

Cartridge Respirators

Cartridge respirators include a fitted rubber facepiece and replaceable filters. Cartridge respirators have a one-way exhalation valve; inhaled air must pass through the cartridge to be filtered, but the valve permits exhaled air to bypass the filters. Facepieces are held in place by at least two adjustable elastic headbands. Half-mask and full-face respirators are two types of cartridge respirators. These cartridge respirators provide good protection against pesticides in the form of droplets, dusts, and vapors. The full-face respirator also provides protection for the face and eyes from pesticide exposure. However, cartridge respirators, even full-face respirators do not offer protection against *fumigants (gases)* unless specifically labeled for fumigants. Even if labeled for fumigants, time of exposure and concentrations of gases, for which protection is given is usually limited. Cartridge respirators cannot be used in atmospheres that are life threatening, such as environments containing carbon dioxide or low oxygen levels.

Cartridges for these type of respirators must have a NIOSH/MSHA “TC” (Tested and Certified) approval number and be designated for use with pesticides. Cartridges made for pesticide use must have two stages:

- 1) a particulate prefilter to mechanically trap airborne particles and
- 2) an activated carbon cartridge to adsorb vapors.

Supplied Air Respirators

Supplied air respirators are used when working with fumigants, in areas with high concentrations of pesticides and when working in other life threatening atmospheres. These devices do not filter the surrounding air through cartridges and filters because they supply an outside sources of clean air. Self-contained supplied air respirators provide clean air from pressurized tanks that the user wears, similar to a scuba diver. External air models connect the wearer to a distant air pump or stationary tank by means of a hose. Air pumps must be located in an area where safe, fresh air is available. Self-contained units are limited to the amount of air that the user can carry. Once the air supply is exhausted, the system cannot provide any protection, therefore these units are equipped with a warning device to alert the user when the air supply is getting low. Air tanks may be heavy and bulky, but they give increased mobility because no hoses are required.

Use and Selection of Respiratory Protective Devices

Pesticide respiratory devices should be used in strict compliance with their manufacturer's recommendations. Information should be requested from the manufacturer regarding use, maintenance, and limitations prior to or upon purchase of a respiratory protective device. Selection of a respiratory protective device must be based upon the various hazards that may exist in a given operation.

Because of the difference in their protective capacities, selection of proper respiratory devices requires consideration of the following factors:

- ✓ nature of the hazard,
- ✓ extent of the hazard,
- ✓ work requirements and conditions,
- ✓ characteristics and limitations of available respiratory protective devices, and
- ✓ pesticide label requirements.

All category I pesticides are regarded as immediately dangerous to life or health. Under most application procedures, respiratory protection against these toxic substances is accomplished with the use of respirators with both chemical and mechanical filters. *Cartridge respirators* should be worn when:

- ✓ pesticides are formulated,
- ✓ pouring concentrated pesticides into a sprayer tank,
- ✓ operators are exposed directly to concentrated dusts, sprays, or aerosols.

For comfort on hot days during the application of concentrated sprays, such as in orchard applications, a half-mask facepiece respirators may be used. To protect the eyes under these conditions, non-fogging, non-perforated goggles should be used.

Cartridge respirators will give adequate protection to airplane pilots during normal spraying operations. However, pilots may find that a self-contained breathing apparatus is more desirable with high concentrations of the more toxic pesticides. If pilots choose to use a half-mask respirator, non-perforated goggles that give a tight seal around the nose piece should be selected.

When applying grain fumigants, a supplied air respirator should be worn while pouring concentrated fumigating material directly on the surface of grains or fumigating below the surface in grain elevators where there is little exchange of air. The supplied air respirator must be connected to an air source free of the toxic material or to a compressed air cylinder.

Most registered herbicides are often regarded as relatively safe to humans, but in fact, herbicides may be toxic, irritating or corrosive in their actions and therefore may present a significant health and respiratory hazard. The pesticide label may specify a minimum requirement for respiratory protection against the herbicide, such as a mechanical filter to trap mists and coarse spray droplets. Some labels may require a mechanical-chemical filter respirator approved for protection for organic vapors.

Training and Education in Proper Use of Respirators

For safe use of any respirator, it is essential that the user be properly instructed in its selection, use and maintenance. All employees should receive instructions from their supervisors.

Minimum training should include the following:

- ➡ Instruction in the nature of the hazard, whether acute, chronic, or both, and an honest appraisal of what may happen if the respirator is not used.

- ➡ A discussion of why this is the proper type of respirator for the particular purpose.
- ➡ A discussion of the respirator's capabilities, limitations, and storage.
- ➡ Instructions and training in the actual use of a respirator and close supervision to assure that it continues to be properly used.
- ➡ Other special training is needed for special uses in certain work conditions. Training should provide the user the opportunity to handle the respirator, have it fitted properly, and tested for facial seal.

Face Piece Fit Tests

A good face piece fit is essential for effective respiratory protection with respirators. A good face seal is not possible when a beard, sideburns, temple pieces on glasses, and skull caps projects under the face piece. The face piece fit should be checked by the wearer each time he/she puts on the respirator. This may be done by following the manufacturer's face piece fitting instructions as follows:

✓Positive Pressure Test

Close the exhalation valve and exhale gently into the face piece. The face fit is considered satisfactory if a slight positive pressure can be built up inside the face piece without any evidence of outward leakage of air at the seal. For most respirators, this method of leak testing requires that the wearer first remove the exhalation valve cover and then carefully replace it after the test.

✓Negative Pressure Test

Close off the inlet opening of the cartridge(s) by covering with the palm of the hand(s) or by replacing with a seal(s). Inhale gently so that the face piece collapses slightly and hold the breath for ten seconds. If the face piece remains in a slightly collapsed condition and no inward leakage of air is detected, the tightness of the respirator is probably satisfactory. A respirator should be fitted properly on the face with the narrow part over the bridge of the nose and the chin cup contacting the under side of the chin. Head bands should be adjusted to insure a good seal.

Maintenance and Care of Respirators

The proper maintenance and care of respirators should include the following basic services:

- ➡ inspection for defects,
- ➡ cleaning and disinfecting,
- ➡ repair as needed, and
- ➡ proper storage.

Equipment which is properly maintained will provide effective protection and will provide longer lasting service. Respiratory protective devices should be inspected routinely before and after each use. Inspection should include a check of tightness of connections and conditions of the face piece, head bands, valves, connecting tube, and canisters. Rubber and elastic straps should be inspected for pliability and signs of deterioration. Rubber and elastic parts can be kept pliable and flexible during storage by routinely applying a massaging action. Respiratory devices should be cleaned after each

day's use. Prior to cleaning, any filters or cartridges should be removed. The face piece and breathing tube should be washed with warm, soapy water, rinsed in fresh water to remove all traces of soap, and sanitized. A residual of sanitizing agent may cause skin irritation and cause accelerated aging of the rubber components. Therefore, a thorough rinsing should accompany the use of a sanitizing agent. For complete decontamination from organophosphate insecticides, the face piece should be washed in a mild detergent solution and rinsed with isopropyl (rubbing) alcohol.

Respirators should be air dried in a clean area separate from pesticide storage or other possible pesticide contamination sources. At this time, valves, straps and other parts can be inspected and defective parts replaced. When dry, the respiratory device, filters and cartridges should be stored in a clean, cool, dry place, preferably in a plastic bag or container.

When using a respirator (e.g. dual cartridge with filter) the cloth filter should be changed twice a day or more often if breathing becomes difficult. Cartridges should be changed after eight hours of actual use or more often if an odor of the pesticide is detected.

Special Problems with Corrective Lenses

Respiratory protection for individuals wearing corrective glasses is a serious problem. A tight seal cannot be established if the temple bars of eyeglasses extend through the sealing edge of the full face piece. A temporary solution is to tape glasses with short temple bars to the wearer's head. **Contact lenses should not be used** in a contaminated atmosphere even with a full-face respirator.

► **Other Features to Consider**

Durability, breathability, color, style and design are all factors that may enter into the choice of protective clothing.

Seams

Uncoated nonwoven garments are usually constructed with serged seams.

▲ Serged Seams: Three threads are interlocked around the edges of two plies of fabric. These seams are not liquid proof, yet they provide protection against dry pesticides.

Coated nonwoven garments can be constructed with bound, sealed or ultrasonic seams.

▲ Bound Seams: The result of enclosing the edges of two separate pieces of fabric and sewing through all layers with a chain stitch. This is one of the toughest seams and provides good liquid splash protection. It does not provide 100% liquid barrier.

▲ Sealed Seams: A very strong, durable seam that is produced when a sewn seam is covered with a heat-sealed or adhesively bonded strip of barrier film material. This seam provides 100% liquid barrier protection.

▲ Ultrasonic Seams: A 100% liquid barrier seam that is produced when two fabrics are lapped together and then thermally or high radio frequency welded.

Breathability

This is extremely important when working in hot environments. Materials such as cotton or the breathable nonwovens offer acceptable comfort in hot and humid environments. However, breathable materials are often less protective than non-breathable materials, so they should not be used with high-toxicity pesticides.

Durability

Limited use suits are not intended to be durable. The fabric, zippers and seams are not the same as those found on reusable suits. Limited use suits are intended to protect you from pesticide exposure, then be disposed of. Reusable coveralls are designed for durability and repeated use. Quality varies, so look for a well-made suit.

Color

If concerned about the public's reaction to the use of pesticides, colors other than white are available. Blue or tan suits may appear less threatening than white "space" suits to some people. Dark colors hide dirt better than light colors and may be more appealing to workers. But if you are located in a hot climate, light colors are better. Dark colors tend to absorb light energy and are hotter to wear on sunny days.

Fit

Coveralls should fit loosely. The loose fit will reduce the risk of pesticide contact with your skin since there is an air space between the clothing and your body. Coveralls should not fit too loosely, however, because they could snag or get caught in a piece of machinery, such as a power take off (PTO). Nor should they fit too tightly. If they are too tight, they limit your movement and are at a greater risk of tearing.

Collars

Protective clothing with collars offers greater protection for the neck and shoulders than clothing without collars.

Flaps

Flaps over the zipper help reduce the amount of pesticides entering the clothing through the zipper area. Some coveralls will have sealing tape under the flap to ensure the pesticide will not enter the zipper area.

Cuff Design

Clothing cuffs should be elastic. This allows a better seal around the glove.

Elastic Leg Closures

Elastic leg closures are not recommended where you will be doing a lot of walking or stepping. As you step, the elastic will cause the clothing's leg to "ride up" and possibly expose the leg.

► Care and Decontamination of Clothing

CHECKLIST

How to properly remove contaminated one-piece coveralls

- Thoroughly wash gloves with soap and water while still wearing them.
- Before removing heavily contaminated waterproof protective clothing, it may be desirable to perform preliminary decontamination by spraying the wearer with a fine mist from a water hose.
- Remove any accessories, such as respirators or goggles.
- Unfasten the protective clothing.
- Take off the gloves.
- Put on a clean pair of gloves.
- Starting at the shoulders, "roll" the protective coveralls down your body. Be careful not to touch the outside. Check to make sure only the inside of the protective clothing is showing by the time it is rolled down to your ankles.
- Take the clothing off the rest of the way and dispose of it according to local regulations or decontaminate it.
- Remove gloves and immediately wash hands.
- Take a shower.

Two-piece suits can be removed just as you would regular clothing, but keep in mind the checklist from the one-piece coverall section. But be sure not to allow the outer contaminated surface to contact the clothing underneath or on your skin. *If the protective clothing has been drenched with a highly toxic pesticide, remove the clothing as quickly as possible and shower immediately.*

| | NON-REUSABLE CLOTHING | REUSABLE CLOTHING |
|------------------------------|---------------------------------|---|
| FREQUENCY OF DECONTAMINATION | NONE | AFTER EVERY USE |
| TRAINING | NONE | PERSONS WHO DECONTAMINATE CLOTHING MUST RECEIVE SPECIAL TRAINING |
| DECONTAMINATION EQUIPMENT | NONE | PPE REQUIRED FOR DECONTAMINATION PROCESS. DESIGNATED WASHING AND DRYING EQUIPMENT. OTHER RELATED DECONTAMINATION EQUIPMENT. |
| TIME | NONE | TIME ALLOTTED FOR DECONTAMINATION PROCESS. |
| CONTAMINATION RISK | RISK DURING REMOVAL OF CLOTHING | RISK OF CONTAMINATION DURING REMOVAL OF CLOTHING. RISK OF CONTAMINATION DURING DECONTAMINATION PROCESS. RISK OF PESTICIDE RESIDUES REMAINING IN CLOTHING AFTER DECONTAMINATION PROCESS. RISK OF CONTAMINATION IF CLOTHING IS DISPOSED OF. |
| PERSONNEL | RISK DURING REMOVAL OF CLOTHING | TRAINED PERSONNEL REQUIRED FOR HANDLING DECONTAMINATION AND DISPOSAL OF CLOTHING. |

Limited Use Clothing

Limited use clothing requires very little care. After use, they are simply disposed. It's critical to properly dispose of clothing that has been contaminated with pesticides. It is recommended that disposable clothing be cut in half to prevent an unsuspecting person from wearing them. Some limited use clothing may be incinerated or discarded in accordance with county and state laws. Be sure to check with your local landfill.

Properly Cleaning Reusable Protective Clothing

Here are some steps on how to clean contaminated fabric clothing.

1. Keep contaminated clothing separate from other clothing.

WARNING:

1. Do not wash limited use coveralls if they have been contaminated with pesticides.
2. Treat contaminated coveralls the same way you would treat the pesticide. Wear gloves and other PPE to protect yourself from pesticide residues on the clothing.

The protective clothing should go in a disposable plastic bag rather than in a cloth bag or laundry basket. Be sure that anyone handling the clothes always wears gloves (8 to 14 mil nitrile gloves are good). Do not dry clean protective clothing. Pesticide contaminated clothing should not be cleaned in public laundry facilities (i.e. coin operated laundromats).

2. Determine whether the clothing can be washed.

Fabric clothing that's saturated with a pesticide concentrate should be incinerated or discarded in accordance with local laws and regulations.

3. Wash clothing daily.

This should be done as soon as possible after it has been worn.

4. Keep the clothing separate from other wash.

Pesticide residues can transfer from contaminated clothing to other clothing that is laundered with it. A separate washing machine is recommended to avoid contaminating regular clothing.

5. Pre-rinse the clothing.

The clothing can be sprayed/hosed outdoors, soaked in a pail or tub not being used for anything else, or agitated in an automatic washing machine.

6. Wash a few garments at a time.

And be sure coveralls contaminated by different pesticides are not washed together.

7. Use the proper washing machine settings.

- hot water temperatures (140 degrees to 160 degrees),
- extra large or large load,
- normal (12 minutes) wash cycle, double rinse.

8. **Use heavy duty laundry detergent.**
9. **Don't add bleach and/or ammonia.**
Mixed together, bleach and ammonia produce a poisonous chlorine gas. Neither helps remove pesticide residues.
10. **Re-wash the clothing two or three times if necessary.**
11. **Thoroughly rinse the machine when done.**
It should be run through an extra complete cycle, using hot water and detergent, even when you have a separate washing machine dedicated to contaminated clothing.
12. **Line dry the protective clothing.**
Do not put any protective clothing in the dryer. Pesticide residues may build up in dryers over time, causing potential serious illness. Line drying is recommended for all protective clothing.

Reusable Coated/laminated Suits

Suits made from materials such as PVC or nitrile should not be decontaminated in a washing machine. Instead, hose them off and wash them in a tub of hot soapy water. Protective clothing made of nitrile, PVC or other rubber-like compounds should be line dried in the shade to keep harmful sunlight from damaging the materials. Suits made from plastic laminates, nitrile or latex may melt if placed in a dryer.

Storage of PPE

Protective clothing should be stored in a clean, dry place away from pesticides and pesticide containers. Avoid exposure to direct sunlight and high temperatures, which may degrade the fabric. Protective clothing should be stored in a special locker, cabinet or other area where it can be kept clean and ready to go. The locker or cabinet should be marked to indicate that the clothing inside is clean.

CHAPTER X

FIRST AID IN THE EVENT OF PESTICIDE POISONING

► First Aid

Speed is essential: A rapid response is critical in any case of potential pesticide poisoning.

1st

- See that the victim is breathing; if not, give artificial respiration.
(make sure you are not coming in contact with the pesticide)

2nd

- Decontaminate the victim immediately, i.e. wash off thoroughly if the pesticide is a liquid. ***Speed is essential!***

3rd

- Call a physician.

Begin first aid treatment by reading the pesticide label for special first aid instructions. All labels contain some type of statement of practical treatment. If additional help is needed, call a physician. The physician will give you instruction. He will very likely tell you to get the victim to the emergency room of a hospital. The equipment needed for proper treatment is there. Only if this is impossible should the physician be called to the site of the accident.

NOTE: Do not substitute first aid for professional treatment. First aid is only to relieve the patient before medical help is reached.

► General Treatment

- Give mouth-to-mouth artificial respiration if breathing has stopped or is labored. However, make sure not to come in contact and expose yourself to the pesticide on the victim.
- Stop exposure to the poison and if poison is on the skin, cleanse the person, including hair and fingernails, making sure you are protected from the pesticide on the victim. If the pesticide is a powder, brush it away but do not wash with water. If swallowed, read label ***before*** vomiting is induced. Some pesticides are corrosive and can cause serious damage to the victim if vomiting is induced.
- Save the pesticide container and any remaining material; get a readable label which contains the name of the chemical for the physician. If the poison is not known, save a sample of the vomitus.

► Specific Treatment

Poison on Skin:

- Drench skin and clothing with water (shower, hose, faucet),
- Remove clothing,
- Cleanse skin and hair thoroughly with soap and water (rapidity in washing is most important in reducing extent of injury),
- Dry and wrap in a blanket.

Poison in Eye:

- ◆ Hold eyelids open, wash eyes with gentle stream of clean running water immediately. Use large amounts of water. Delay of a few seconds greatly increases extent of injury,
- ◆ Continue washing for 15 minutes or more,
- ◆ Do not use chemicals or drugs (i.e. commercial eye washes) in the wash water. They may increase the extent of the injury.

Inhaled Poisons (Dusts, Vapors, Gases):

- If the victim is in enclosed space, do not go in after him/her without an air supplied respirator,
- Carry victim (do not let him/her walk) to fresh air immediately,
- Loosen all tight clothing,
- Apply artificial respiration if breathing has stopped or is irregular,
- Call a physician,
- Prevent chilling by wrapping the victim in blankets but don't overheat him or her,
- Keep the victim as quiet as possible,
- If the victim is convulsing, watch his/her breathing and protect him/her from falling and striking his/her head. Keep his/her chin up, and keep the air passage free for breathing,
- Do not give alcohol in any form.

Swallowed Poisons:

- ◆ Call a physician immediately,
- ◆ Do not induce vomiting if:
 - * the victim is in a coma or unconscious.
 - * the victim is having convulsions.
 - * the victim has swallowed petroleum products (that is, kerosene, gasoline, lighter fluid).
 - * the victim has swallowed a corrosive poison (strong acid or alkaline products)
[symptoms: severe pain, burning sensation in mouth and throat.]
- ◆ If the victim can swallow after ingesting a corrosive poison, (a corrosive substance is any material which in contact with living tissue will cause destruction of tissue by chemical action, such as lye, acids, Lysol, etc.) give the following substances by mouth:
 - * For Acids: milk, water, or milk of magnesia (1 tablespoon to 1 cup of water),
 - * For Alkali: milk or water; for victims 1-5 years old, 1 to 2 cups; for victims 5 years and older, up to 1 quart.

- ◆ If possible, induce vomiting when a *noncorrosive substance* has been swallowed.
 - * Give milk or water (1 quart for an adult or a large glass for a child under 7),
 - * Induce vomiting by placing the blunt end of a spoon (not the handle) or your finger at the back of the victim's throat, or by use of an emetic, such as syrup of ipecac.
 - * When twitching and vomiting begin, place victim face down with head lowered, thus preventing vomitus from entering the lungs and causing further damage. Do not let the victim lie on his or her back,
 - * *Do not waste excessive time in inducing vomiting if the hospital is nearby.* It is better to spend the time getting the victim to the hospital where drugs can be administered to induce vomiting and/or stomach pumps are available, and
 - * Clean vomitus from the victim. Collect some in case the physician needs it for chemical tests.

Chemical Skin Burns:

- Remove contaminated clothing,
- Wash with large quantities of running water,
- Immediately cover with loosely applied *clean* cloth or blanket depending on the size of the area burned,
- Avoid the use of ointments, greases, powders, and other drugs in first aid treatment of burns, and
- Treat shock by keeping the victim flat, warm, and reassuring them until arrival of physician.

POISON CONTROL CENTERS

In Montana, the Poison Control Systems telephone number is **1-800-525-5042**. The Emergency Medical Services Bureau (EMS) of the Montana Department Environmental Quality in Helena will provide telephone stickers with the Poison Control phone number free of charge.

CHAPTER XI

PESTICIDES AND THE ENVIRONMENT

Pesticides are an effective tool and provide an efficient means to control pests when used correctly and with care. When pesticides are misapplied or applied carelessly, harm to the environment may occur. Even when pesticides are applied in accordance with the label, environmental damage can result. Organochlorine insecticides, such as DDT, have been found to persist in the environment for years. Residues of DDT can still be found in soils, water and animal tissues even though registration of DDT was suspended in 1972. Some herbicides, such as picloram acid and triazines have the potential to leach and contaminate ground water.

It is important to remember that every pesticide has the potential to harm the environment. When a pesticide is applied, any of the following can occur:

- movement of the pesticide by drift to off-target organisms, plants, water and soil;
- removal of the pesticide from an application site when runoff, leaching or wind or water erosion occurs;
- accumulation of residues in soils as a result of repeated applications over time;
- movement from one location to another from contaminated machinery and equipment; and
- transfer of raw agricultural commodities having pesticide residues to food processing centers, feed lots, consumers and wildlife.

With public attention focused on the damage pesticides can impose upon the environment, all applicators must act as stewards of the environment. Environmental stewardship means using pesticides correctly, being aware of the potential for pesticides to damage the environment and then making every effort to prevent damage or contamination. An understanding of the fate of pesticides in the environment enables pesticide users to make informed decisions concerning their use.

► **Pesticide Fate**

Because, to some degree, pesticides behave in predictable ways in the environment, it is possible, when pesticide fate mechanisms are understood, to achieve greater control and management of pesticides, providing better protection of environmental resources. All pesticides are subject to breakdown over time. Pesticides may be degraded by a single mechanism, such as photodegradation, chemical reactions or microbial consumption, or by a combination of mechanisms. During the breakdown process, pesticides are reduced to secondary products. Secondary products are often referred to as degradates, metabolites or breakdown products. Metabolites may or may not exhibit pest control properties. While many pesticides break down to harmless secondary products, some pesticide metabolites are more toxic than their parent compound. The breakdown process continues from secondary products to tertiary products and so on, until, eventually, they are reduced to harmless products. The length of time required for completion of this process is called **persistence**. Persistence varies with the pesticide product. Organochlorine pesticides, such as DDT, aldrin, dieldrin and endrin, are quite persistent, while malathion and 2,4-D are examples of short lived

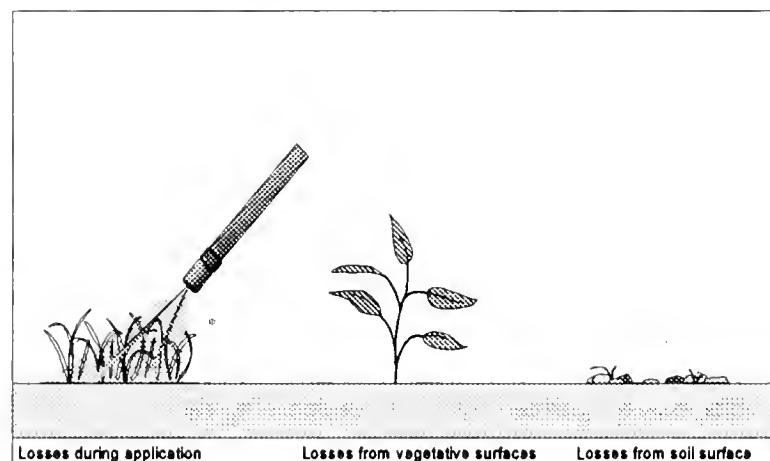
pesticides. Persistence is also a function of other environmental factors: soil type, soil pH, soil constituents, microorganisms, sunlight, weather, and application rates. Temik, an insecticide applied in the soil, breaks down more quickly in sandy than in clay soil. Imazamethabenz-methyl (Assert), a herbicide, reportedly breaks down quickly in the presence of sunlight. In the soil environment, imazamethabenz-methyl breaks down more slowly as soil pH increases, soil temperatures decrease and in the presence of soil calcium bicarbonate.

Volatilization

Pesticides may vaporize from both soil and vegetative surfaces. Volatilization is affected by temperature, as the temperature increases the potential for volatilization also increases. Pesticides may vaporize before they reach the vegetation, as shown in the figure below. Because leaf surface temperature is often higher than surrounding ambient air temperature, vaporization may occur as pesticides dry on vegetative surfaces. Volatilization after application decreases over time as pesticide uptake into the plant occurs.

Pesticide vapor pressure will determine the potential for a compound to vaporize and enter the atmosphere. Pesticide vapor pressure indexes are used to determine the vaporization potential of

pesticides from application and vegetation surfaces. Pesticide sorption and vapor pressure will determine the volatilization potential from dry soils. Generally, pesticides having vapor pressure indexes (VPI) of less than 10 are least likely to volatilize from dry soils, while those with VPIs greater than 1,000 will have the greatest potential to volatilize.



Soil moisture content and pesticide water solubility must also be considered when determining the

volatilization potential from a moist soil. Henry's Law Constant values (K_h) are used to indicate volatilization potential from moist soils. When the Henry's Law Constant value for a pesticide is less than 100, losses through volatilization will likely be minimal. Volatilization losses can be expected to be high if the Henry's Law Constant value exceeds 10,000.

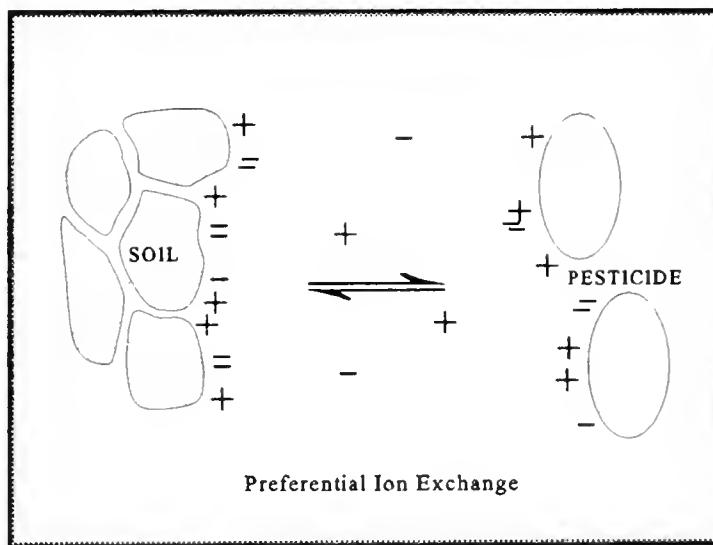
Vapor Pressure and Henry's Law Constant for Selected Pesticides
(Oregon State University, 1994)

| Name of Pesticide | Vapor Pressure (mm Hg x E+07) | Henry's Law Constant (Kh x E+09) |
|------------------------|----------------------------------|-------------------------------------|
| Aldicarb (Temik) | 300.0 | 51.0 |
| Benomyl (Benomyl) | 0.001 | 0.78 |
| Carbaryl (Sevin) | 10.8 | 250.0 |
| Carbofuran (Furadan) | 6.0 | 20.0 |
| Diazinon | 600.0 | 16,000.0 |
| Glyphosate (Roundup) | 0.0 | 0.0 |
| Malathion (Cythion) | 80.0 | 1,000.0 |
| Metalaxyl (Ridomil) | 56.2 | 10.0 |
| Methyl Bromide | 18.0 | 700.0 |
| Picloram salt (Tordon) | 0.0 | 0.0 |
| Permethrin (Ambush) | 0.13 | 46,000.0 |
| Trifluralin (Treflan) | 1,100.0 | 6.6 |

Sorption

Soil sorption involves both absorption (into, as happens when water is imbibed by a sponge) and adsorption (onto, as happens when a plastic ball is painted) of a pesticide into or onto soil particles. Sorption is influenced by soil texture, organic matter content and soil moisture. Soils with clay particles and organic matter are more likely to absorb or adsorb due to a large, chemically active surface area. Sand particles have smaller area surfaces and are unlikely to be chemically active enough to provide effective degradation of pesticide products through sorption processes.

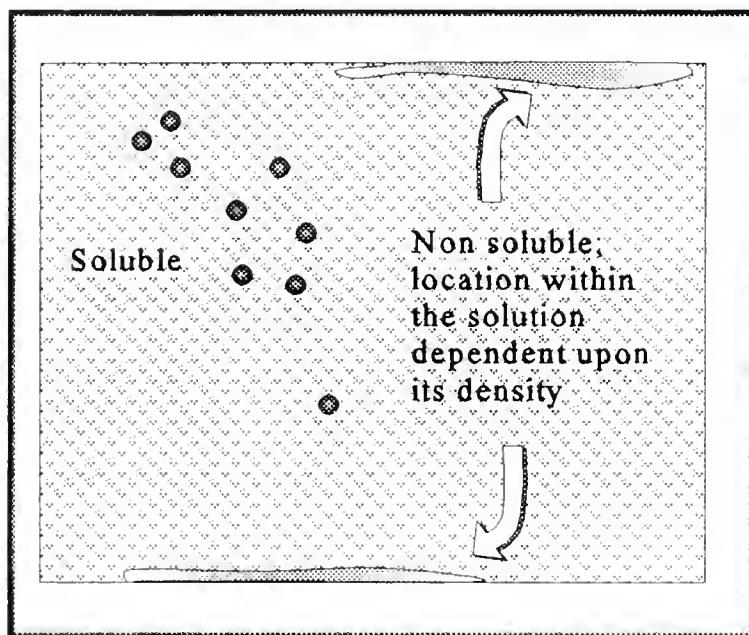
Sorption is the preferential exchange of cations (positively charged) and anions (negatively charged) between the pesticide, soil particles and organic material. The strength of attraction between ions of the pesticides and the soil is dependent upon the characteristics of the ion or



Preferential Ion Exchange

ions in question. The strength of those attractions determine the amount of preferential exchange that will occur. The charge of the soil matrix and the pesticide(s) is also important in determining the potential for sorption to proceed. Pesticides will have positive, negative or neutral charges. Montana soils have a net negative charge. Sorption potential is somewhat similar to the charge of magnets; like charges will repel one another while a strong attraction exists between negative and positive charges. Because of the overall net negative charge of Montana soils, preferential exchange will favor positively charged pesticides. Sorption processes result in structural loss or breakdown of the pesticide to soil or organic matter particles.

The sorption distribution coefficient (K_{oc}) is often used to compare the sorption potential of different pesticides. The higher the K_{oc} value, the stronger the sorption potential. For example, dicamba salts have a very low sorption coefficient (K_{oc}) of only 2, thus the potential for sorption to occur is poor. Benomyl, however, has a K_{oc} value of 1900, a high sorption coefficient and can be expected to exhibit more sorption potential. Pesticides that exhibit a high potential for sorption are more likely to bind to soil or organic matter particles and, therefore, are less likely to move from the application site and cause off target damage.



2,100,000 ppm. The more soluble a pesticide is, the more likely movement from the application site could occur.

Hydrolysis

Hydrolysis is the dividing of a chemical molecule bond in the presence of water, resulting in a substitution and the formation of a new bond with the oxygen atoms of the water. The process of hydrolysis, as well as the rate of hydrolysis, will vary with the acidity or alkalinity of the soil environment. The resulting altered pesticide compounds may or may not have pesticidal properties.

Solubility

Pesticide water solubility refers to the capacity of a pesticide to dissolve in water [see the figure at left]. Solubility of pesticides is influenced by temperature, pH, and the presence of other chemicals and constituents (naturally occurring components of water, for example iron, calcium, nitrogen, sodium). Rate of dissolution into water is determined by the current load (i.e., how much is already there) of dissolved pesticide present in solution. Solubility is expressed in milligrams per liter of water (mg/L) or parts per million (ppm). For example, Temephos has an extremely low solubility of 0.001 ppm while triclopyr (amine salt) has a solubility of

Photodegradation

Many pesticides will breakdown in the presence of sunlight. The rate and extent of photodegradation is dependent upon the intensity of the sunlight and the position of the pesticide in the environment. Pesticides located on upper leaf surfaces will be more subject to the effects of sunlight than those within the leaf canopy. Similarly, the depth of the pesticide within a body of water will determine the potential for photodegradation.

Soil Half-Life

Persistence refers to how long the pesticide will be present in the environment. The soil half-life ($T_{1/2}$) of a pesticide is the amount of time required for 50 percent of a pesticide to decompose to products other than the original. Pesticides having a soil half life of 30 days or less are considered to be non-persistent. Moderately persistent pesticides have a soil half-life of 30 to 99 days and those with a soil half-life of more than 100 days are considered to be persistent. Generally, the longer a pesticide persists, the more likely it is that impairment or contamination of the environment will occur.

Pesticide persistence ratings.

| | |
|-------------|-------------------------|
| < 30 days | → non-persistent |
| 30- 99 days | → moderately persistent |
| > 100 days | → persistent |

► Pesticide Residues in Food and Water

The amount of any pesticide or its breakdown products in or on soil, air, water, plants, and animals at any point in time is a **residue**. All pesticide applications result in residues. However, the "life" (the length of time that a residue remains) is directly related to the pesticide's persistence. Residues are commonly expressed in terms of parts per million (ppm) by weight. Advances in research techniques have made it possible to detect certain pesticides at levels approaching 0.001 ppm or 1 part per billion (ppb). To illustrate size, 1 ppm is less than 1 teaspoon in 1,000 gallons; 1 ppb is 1.5 cubic inches of water in the Fort Peck Reservoir (6,322,460 gallons).

EPA determines the amount of allowable residue that may be in or on raw agricultural commodities. Allowable legal residues are called **tolerances**. Tolerances are established in parts per million by weight and are specific for both the pesticide and the crop. For example, aldicarb, an insecticide, has an established pesticide tolerance of 1 ppm for potatoes, 0.05 ppm for peanuts and 0.3 ppm for bananas. Similarly the crop tolerances for captan, sesone and diazinon on strawberries are 25 ppm, 2 ppm and 0.5 ppm, respectively. Pesticides applied in accordance with directions printed on the label should not result in residues that exceed legal tolerances. When misapplied, illegal tolerances can occur, as happened when the pesticide aldicarb, which is not labeled for use on watermelons, was applied to watermelons in the 1980s.

Some pesticide labels list required *time intervals* between date of application and harvest, milking, slaughter, or re-entry onto the premises. Violation of these time intervals can result in illegal residue levels for commodities and may present a health risk to workers and consumers.

Washing, scrubbing, and various food processing procedures, such as peeling and cooking of fruits and vegetables, can reduce the amount of residue remaining on food prior to consumption. Changes in a commodity condition can result in increases or decreases of residues. Dehydration in fruit and vegetables results in a loss of water, which reduces the weight of the product, altering the ratio of chemical residue by weight. This difference may be great enough to exceed legal tolerances.

Drinking water maximum contaminant levels (MCLs), health advisories (HAs), and interim standards have been established for many pesticide products. These standards indicate the level which, if ingested over an extended period of time, will not pose a risk to human health. For some pesticides, such as parathion, levels lower than the health risk based standard were adopted due to taste and odor problems.

♦ **Pesticide Residues in the Environment**

Air Impairment

The major source of air pollution by pesticides is through direct ground and aerial application. Factors which affect the amount of pesticide entering the atmosphere from a pesticide application are pesticide type and formulation, application equipment, method of application and weather conditions. Pesticides can enter the atmosphere through drift, volatilization and wind erosion processes.

Pesticides that have become part of the general atmospheric circulation are transported over vast areas. Although the pesticide burden of the general circulating atmosphere does not appear to pose any serious environmental dangers, localized drift from both aerial and ground applications of pesticides has resulted in significant economic and environmental losses. A number of incidents occur each year in Montana involving drift of phenoxy herbicides from ground and aerial applications. These incidents often cause nontarget crop and plant damage.

Water Resources

Pesticides may enter water resources through direct application to control aquatic pests, misapplication, spillage, accidents, back siphonage, drift, runoff, leaching and by improper disposal. Water which is contaminated with pesticides may directly and indirectly affect human health, domestic and wild animal health, and crops.

Soil Contamination

The effects of pesticides in soil can be short to long-term in nature. Factors which determine the persistence of pesticides in the soil include the chemical characteristics of the pesticide; pesticide application amount and method; soil type, structure, moisture, temperature, organic matter and constituents; microorganisms; cultivation, land and irrigation management practices; wind and air movement; and vegetation cover. Of these factors, pesticide and soil characteristics have the greatest effect on persistence.

Application of a pesticide with a long residual life and high sorption potential can lead to residue accumulation in the soil environment when these pesticides are applied on a regular basis over an

extended period of time. Crop injury can occur when sensitive crops are rotated into fields with residual accumulation. When soil residues build, the soil's capacity to retain them can be exceeded, resulting in leaching of residues with mass water movement from high precipitation events (rainfall and irrigation).

► **Surface Water**

Montana has a total land surface area of approximately 147,046 square miles. Approximately 1,490 square miles of that is surface water. There are an estimated 53,000 miles of perennial streams and rivers in Montana. Montana has more than 10,000 lakes and reservoirs and countless other smaller water bodies, such as wetlands. The estimated number of livestock ponds in Montana is to be in excess of 38,000.

In Montana up to ten million gallons per day (mgd) of surface water are used for irrigation, 83 mgd for public water supply, 1 mgd for rural domestic use and 35 mgd for livestock. Montana surface waters also provide habitat for a variety of wildlife, support aquatic life, provide hunting and fishing and other recreational opportunities, and serve as commercial fisheries.

Pesticide contamination of surface waters can occur as a result of:

- misapplication of pesticides directly onto surface water,
- drifting of pesticide onto surface waters,
- wind erosion depositing soil bound with pesticides onto surface waters, and
- overland water movement or drainage resulting from erosion, flooding, precipitation or irrigation.

Contamination of surface water by pesticides may effect domestic stock, wildlife, fish and aquatic organism health. The resulting quality of livestock meat, egg and milk products may be reduced or rendered unusable and unsaleable. Contaminated irrigation water may seriously affect crops.

► **Ground Water**

Ground water is the drinking water source for 50% of Montana citizens and 95% of those living in agricultural communities. Whenever pesticides are used, the potential for ground water contamination exists. Protecting this fragile resource is imperative. Cleanup of ground water resources is difficult and, if possible, very expensive. Some pesticides may cause human health impacts, even at low concentrations. For these reasons, pesticide users should be aware of the potential for a pesticide to leach and contaminate ground water.

Both pesticide characteristics and local geological and soil conditions play an important role in whether or not pesticides **leach** (move or seep) to ground water resources. Deep soil environments provide more opportunities for pesticide degradation to occur than shallow soil systems. Soil environments rich in clay and organic matter promote degradation of pesticides and their metabolites.

Pesticide solubility, sorption potential, and soil half-life are probably the most important indicators of pesticide behavior in a soil environment. Pesticides which exhibit high solubility, low sorption and

moderate to long persistence (half-life) are more likely to leach or move with water through the soil profile. When considering the potential of a pesticide to leach, the user should look at all available information. Taken separately, one pesticide individual characteristic may not accurately reflect a pesticide's potential to leach. For example, the solubility of glyphosate is 90,000 ppm, highly soluble. If this information alone were used to assess the leaching potential, it would result in an assumption that glyphosate has a high potential to leach. However, the sorption potential of glyphosate is 24,000 ml/g, indicating a very strong soil sorption affinity. Solubility is counterbalanced by a strong sorption potential and a moderate half-life of 47 days. In fact, glyphosate has a very low leaching potential. Solubility, soil half-life, sorption (K_{oc}), and pesticides may be found in Table 11.1.

The MDA has been monitoring ground water for the presence of pesticides since 1984. MCPA, bromacil, 2,4-D, aldicarb, simazine, PCP, atrazine, picloram (Tordon), dicamba (Banvel), clopyralid (Transline and Curtail), diuron, imazapyr, prometon and imazamethabenz-methyl (Assert) are among some of the pesticides detected in Montana ground water. Most pesticide detections in Montana have low level concentrations, do not exceed established standards and do not pose a threat to human health from consumption. Nevertheless, pesticide presence in ground water should not be considered an acceptable end result of pesticide use.

When the verified presence of any pesticide is detected in a water resource as a result of monitoring or investigative activities, the MDA will determine the cause and extent of contamination. The MDA will also determine if the presence of a pesticide in a water resource (surface or ground water) is a point or non-point source.

Table 11.1

Selected pesticide properties which influence leaching (values are not absolute). (Chemical and Pharmaceutical Press, 1990; Meister Publishing Co., 1992; USDA-ARS, 1990; USDA-SCS, 1990 and Wauchope, 1990)

| Pesticide | S (ppm)* | $T_{1/2}$ (days) | K_{oc} (ml/g) | Leaching Potential |
|---------------|----------|------------------|-----------------|--------------------|
| Atrazine | 33.0 | 120 | 100 | High |
| Carbaryl | 120.0 | 10 | 157 | Low |
| Clopyralid | 1,000.0 | 30 | 6 | High |
| 2,4-D Acid | 890.0 | 10 | 80 | Medium |
| Diazinon | 65.0 | 31 | 500 | Medium |
| Dicamba | 6,500.0 | 20 | 8 | High |
| Dimethoate | 25,000.0 | 7 | 8 | Medium |
| EPTC | 375.0 | 30 | 280 | Medium |
| Fluazifop | 2.0 | 15 | 5,700 | Low |
| Glyphosate | 90,000.0 | 50 | 24,000 | Low |
| Malathion | 145.0 | 1 | 1,800 | Low |
| Metribuzin | 1,220.0 | 30 | 41 | High |
| Metsulfuron | 6,000.0 | 105 | 40 | High |
| Pendimethalin | .3 | 90 | 24,300 | Low |
| Permethrin | .2 | 32 | 86,000 | Low |
| Picloram | 430.0 | 200 | 16 | High |
| Triallate | 4.0 | 82 | 2,400 | Low |
| Trifluralin | .3 | 90 | 7,000 | Low |

* S = Water Solubility $T_{1/2}$ = Soil Half-life K_{oc} = Soil Sorption

Point source by definition in the Montana Water Quality Act, 75-5-103, MCA, means any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, or vessel or other floating craft, from which pollutants are or may be discharged. The Montana Pesticide Act, 80-15-102, MCA, adds that point source means a point source as defined in 75-5-103, MCA, including but not limited to chemical mixing, loading, and storage sites and sites of agricultural spills. Corrective actions are taken to resolve point source contamination.

Non-point source by definition in the MPA, 80-15-102, MCA, means a diffuse source of agricultural chemicals resulting from human activities over a relatively large area, the effects of which must normally be addressed or controlled by a management or conservation practice. Appropriate management actions are taken to prevent further contamination and to minimize or mitigate the presence of non-point source pesticides in ground water.

♦ **Best Management Practices**

Best management practices (BMP) are practices that the applicator or user can do to prevent, reduce, and minimize contamination to the environment when applying pesticides. The following are a few that pesticide users should keep in mind:

- ✓ Be sure that you have a pest problem that pesticides are effective on. Leaf discoloration resulting from nutrient problems can not be corrected by the application of pesticides. Investigate discoloration to determine if it is actually caused by an insect, disease, or nutrient deficiency or excess.
- ✓ Match pesticide selection to the pest insect and the plant or crop.
- ✓ Use pesticides only when there is a definite need for pest control and there are no feasible alternatives.
- ✓ Apply pesticides as specific treatments, not as general remedies, by using pesticides only on the affected plants or crops within a field or area.
- ✓ Time pesticide applications when they will be most effective.
- ✓ Consider pesticide characteristics and their expected behavior in the environment when selecting a pesticide.
- ✓ Follow all label directions on or attached to the pesticide container.
- ✓ Do not apply more than needed. A thorough application at recommended dosage rates is more effective than an excessive amount applied in a haphazard fashion.
- ✓ Reduce disposal needs by mixing only the amount of spray you need.
- ✓ Properly dispose of all surplus pesticide and pesticide containers.
- ✓ Be aware of any and all consequences that may develop as a result of an application of a pesticide.

CHAPTER XII

FISH AND WILDLIFE

♦ Nontarget Effects of Pesticides

Wildlife, fish, beneficial insects and desirable plants commonly occupy, use or border sites where pesticides may be applied to control a pest. Few pesticides are so specific that they affect only the target pest. While some pesticides affect only a closely related group of plants or animals, many are broad spectrum. An organophosphate insecticide used for grasshopper control on pasture land is intended to kill only grasshoppers. However, beneficial insects, birds and mammals that are present on the application site or use the site shortly after application also may be killed or adversely affected. The insecticide may move from the application site by drift or runoff into streams or ponds causing death to fish and aquatic insects. Impacts to nontarget organisms from the use of pesticides can often be avoided or greatly reduced by implementing pesticide application decisions that reduce exposure or dose. These decisions can include the choice of a less toxic pesticide, a reduced rate of application, timing of the application, prevention of off-target movement and other risk reduction measures.

The ability of a pesticide to harm wildlife and other nontarget organisms depends on a number of factors:

Mode of Action: This is the particular way a pesticide acts on an organism. A herbicide that kills plants by disrupting the process of photosynthesis will unlikely cause an adverse effect on animals that may be exposed to a label recommended application rate that will kill plants.

Toxicity: This is the ability of a pesticide or any other chemical to cause injury. Toxicity is often measured using an LD₅₀ value. The lower the LD₅₀ value the more toxic the chemical or the greater its potential to cause harm. Toxicity of a pesticide only tells us about its potential to cause harm. Whether a pesticide actually causes harm depends on other factors, such as exposure and dose.

Exposure: This is the amount of pesticide that contacts a plant or animal. An animal, such as a bird species that might be killed or injured if exposed to a highly toxic organophosphate insecticide, will be unharmed if it is not present on the application site during or within a certain period after the application occurs. The bird's use of the site may be seasonal or unlikely because it is not preferred habitat. Therefore, the timing of a pesticide application and knowledge of an animal's general biology and habitat preferences are important in minimizing exposure to many nontarget organisms.

Use of a broadleaf herbicide to control a pest plant on a rangeland site has the potential to kill desirable nontarget plants in the same area. Use of spot application to target the pest plant and use of techniques to reduce spray drift can permit control of the pest plant while reducing or eliminating exposure to nontarget plants nearby.

Dose: This is the amount of pesticide that is actually absorbed into the tissue of an animal or plant. The dose is dependent on the pesticide's ability to move across the skin, digestive tract or lungs of an animal or the cuticle of a plant and the amount of exposure the animal or plant receives.

Dose is also related to size. A beneficial predator insect in an alfalfa field may be killed by an insecticide application to control aphids. A rabbit, occupying the alfalfa field and exposed to the same application, may show no visible effect because the dose it received was so small in relation to its body size that a toxic effect does not occur. The effect of a given dose is also affected by toxicity. If the insecticide used in this same example is highly toxic, it might, in fact, cause the death of the rabbit either by direct exposure or consumption of the insecticide residue on the alfalfa.

► **How Does Exposure to Wildlife Occur?**

Primary Exposure: This is direct exposure to a pesticide. It may occur by contact of a pesticide spray to skin or when animals brush against treated plants. Direct exposure may occur when a pesticide volatilizes and is then breathed in by animals. Pesticides may also be ingested when animals graze on treated plants or consume the pesticide directly, such as granular formulations that are mistaken by birds for grit or seeds. Direct exposure can occur when animals drink from or bathe in pools of water that have been contaminated by spills, drift or runoff.

Secondary Exposure: A pesticide is generally absorbed into the tissue of a plant or animal, where the lethal effect occurs. The pesticide may remain in its original form or occur as one or more metabolites. The pesticide remains toxic in the tissue for a period of time until degradation occurs. The length of time for degradation to occur depends on the stability of the pesticide itself as well as environmental factors that effect degradation. An animal eating a plant or another animal containing a pesticide in its tissue will be exposed to the toxic effects of that pesticide. This may occur when grasshoppers consume vegetation treated with an insecticide for the control of grasshoppers. The grasshoppers fed to nestling birds contain some of the insecticide within their tissue. Whether the nestlings are adversely affected depends on the dose and the insecticide's toxicity.

Secondary exposure is often used to describe what is actually a primary exposure. An example of this is illustrated when a ground squirrel is killed by consuming a rodenticide bait. In many cases the digestive tract of a ground squirrel carcass may contain a substantial quantity of the undigested bait. A fox that may eat the ground squirrel carcass is exposed directly to the rodenticide bait in the gut. This is a primary exposure of the fox to the rodenticide even though it received it secondarily through the ground squirrel carcass. Again, whether the fox is adversely affected depends on the dose and the rodenticide's toxicity.

► **How Do Pesticides Affect Wildlife?**

The effects of pesticides to wildlife and other nontarget organisms can generally be classified into one of two categories, either acute or sublethal.

Acute Effects: Acute effects are those that result in death or obvious injury or impairment from a single or short term contact with a pesticide. Acute effects are most commonly associated with pesticides that are highly toxic (low LD₅₀ values). In most peoples' minds, acute effects to nontarget are generally associated with insecticides or rodenticides, and, in fact, most examples of nontarget deaths to animals from pesticides can be attributed to these classes of pesticides.

Honey bees are very susceptible to being killed when insecticides are used in blooming crops for control of insect pests or if the insecticide drifts from an application site onto areas used by bees. Use of highly toxic insecticides, such as parathion, carbofuran or aldicarb, may cause the death of birds and small mammals living on the application site where there is a high probability they may be directly exposed to the insecticide. Fish are often very sensitive to low concentrations of certain pesticides in water. Some pesticide labels may have application setbacks that may range from 30 to 100 feet for ground application to one-quarter mile for aerial application to prevent contamination of aquatic habitats. The aquatic herbicides acrolein and xylene used to control aquatic weeds in irrigation canals are extremely toxic to fish and aquatic insects. Accidental releases of treated canal water into streams have caused significant fish kills.

Chronic or Sublethal Effects: Exposure to small doses of pesticide over a period of months or years may cause adverse effects that are not readily observable. If chronic (repeated) exposure to small doses of pesticide is causing a detrimental effect to nontarget organisms, it may be very difficult to determine. Whether a population of animals is being harmed by chronic pesticide exposure might be expressed by whether the population numbers remain constant or are expanding or if they are declining. However, many factors affect the health of wildlife populations including food abundance, weather, availability of suitable habitat and predation pressure. Whether exposure to pesticides may be causing a decline in wildlife populations or to what degree is difficult to distinguish from other environmental stresses that may be causing or contributing to population declines. Sublethal exposure to pesticides may not, by themselves, cause significant effects but in combination with other pressures they may add enough additional pressure to result in a decline of a wildlife population.

Determining if chronic exposure to pesticide causes adverse effects to wildlife, and to what extent, requires careful scientific study. Susceptibility among species varies considerably and an effect that might be observed in one species cannot be applied reliably to another species. Some effects of pesticides to wildlife that have been documented for some pesticides in some species include:

Reproduction - fewer young born, lighter birth weights, low survival rates;

Behavior - decreased ability to avoid predators, changes in breeding behavior, slower learning, decreased parental care of young;

Physiological - cholinesterase inhibition from exposure to organophosphate insecticides, resulting in increased levels of acetylcholine, which causes increased excitability; and

Other effects which may occur but are poorly documented include increased susceptibility to diseases and other stresses, birth defects, mutations and cancer.

► Biological Magnification

Biological magnification is the movement and increase in concentration of a pesticide from one level of a food chain to another. Animals at the top of a food chain, usually predators, may accumulate concentrations of a pesticide from the foods that they consume that become high enough to cause an adverse effect. This may occur even though the animal may have never been exposed directly to the pesticide. Pesticide characteristics that permit biomagnification are stability and solubility in fats. The organochlorine class of pesticides that include DDT, toxaphene, chlordane and endrin are persistent and fat soluble and are well known for their ability to move and increase in concentration through the food chain.

Most pesticides with the ability to bioaccumulate have been removed from use in the United States and replaced with pesticides that degrade quickly and have low solubility in fats. Pesticides with these characteristics are generally excreted from the body quickly. Although there may be some transfer in the food chain, increases in concentration seldom occur. Many years after cancellation of most organochlorine pesticides, they are still detected in the tissues of some animals, although usually at low concentrations. This illustrates the persistent nature of these compounds and their ability to move through the food chain, even years after use has stopped.

► Habitat Alteration and Loss of Food

Changes in habitat and loss of food used by wildlife caused by the use of pesticides can be just as detrimental to wildlife populations as direct exposure to pesticides. All wildlife depends on certain types of food sources and certain habitat types for survival and wildlife will decline or be eliminated if they are removed. Changing the nature of a habitat, whether by the use of pesticides or other means, is often a deliberate choice and the consequences to wildlife can be predicted. Application of a herbicide to sagebrush to increase grass production on rangeland will decrease or eliminate the presence of those species that prefer a sagebrush habitat (i.e., some song birds, sage grouse and browsers, such as pronghorn antelope). Other changes in habitat that causes harm to wildlife may be less obvious. Removal of plants that support insects that in turn are critically important as food for nestlings or young birds will result in low brood survival if they are unable to adapt to other food sources or if other food sources are not available. Plants along a fence line that produce seed used by pheasants during the winter may result in low winter survival by the pheasants if the plants were removed by a herbicide application.

These and other examples of pesticide applications that effect wildlife may have been appropriate actions for management of pest problems but resulted in unintentional adverse impacts to wildlife populations.

► Reducing Risk to Wildlife

Pesticides, by their very nature, because they are intended to kill, present a potential risk to nontarget plants and animals. The first step in reducing risks to nontarget is to understand that a pesticide may harm organisms other than the target pest. We also need to know what nontarget plants and animals may be exposed to a pesticide application and how they are affected by it. With this knowledge, choices and actions can be taken in how pesticides are used to reduce potential harm to nontargets.

Even though a pesticide is highly toxic to certain nontarget organisms, there may be decisions about application methods, application timing, application rates, or other actions that can eliminate or greatly reduce nontarget injury. In other words, risk can be managed by the following:

- Read and understand the pesticide label. Label statements may indicate that the product is toxic to birds, or fish, or bees or will harm sensitive plants. Specific use directions and environmental precautions for protection of wildlife are frequently found on pesticide labels. These may include application set backs from aquatic sites, prohibiting direct application to water, or warnings against runoff. Following the label does not guarantee wildlife will not be harmed, but following label precautions reduces the risk. It also gives the user information about what nontarget species are most susceptible to that pesticide product.
- Use the least toxic pesticides. For many pest problems, there may be few pesticide alternatives. In other cases, there may be a range of pesticide products from which to choose. Those that are the least toxic, while still providing pest control, should be considered for use. In some cases, the least toxic pest control choice may not be the most economical or may be effective only during certain stages of the pest's life cycle. Use of least toxic pesticides may also require close attention to crop growth and pest development.
- Consider the potential for movement of the pesticide off the application site. This may occur by runoff after irrigation or precipitation. Terracing fields, leaving vegetated strips along field edges and avoiding excess irrigation can prevent pesticide movement to ponds and streams. Apply pesticide sprays during situations not conducive to drift off the application site.
- Dispose of pesticides and pesticide containers properly. Store excess pesticide mixtures for use at a later time. Triple or power rinse containers when they are empty. Dispose of them at a licensed landfill or offer them for recycling.
- When cleaning spray equipment, do not permit rinsate to pool into puddles that may be available for pets and wildlife for drinking or bathing.
- Use a back flow prevention device whenever drawing water from streams or ponds to fill spray equipment.
- Granular pesticides are often attractive to birds that may mistake them for food or grit. Thorough and complete incorporation is important to remove granulars from sight. Pay particular attention to row ends and equipment fill sites. Clean up spills and consider making extra passes on field ends to ensure complete incorporation.
- Survey your property for roost sites, feeding areas, attractive wildlife habitat, migratory bird stop over sites and other places wildlife is known to frequent. Consider application setbacks around these areas or time applications when wildlife will not be present.

► The presence of wildlife can be actively discouraged on a pesticide application site. Hazing and scare techniques can be used to move animals from, or prevent their use of, a site prior, during or after a pesticide application. Techniques that might be used include scare devices, such as reflective Mylar strips or balloons, propane exploder scare guns, mechanical scarecrows, randomly timed flashing lights and noise, foot or vehicle patrols and other activities intended to temporarily frighten animals. Scare techniques work best on larger animals, such as deer, predators such as hawks or fox, waterfowl and flocks of migratory birds. These techniques are usually only effective for a short time before animals become used to them and should not be expected to work all season long. Scare techniques should not be expected to work on small mammals, song birds or upland game birds.

► Use integrated pest management (IPM) techniques. IPM is a pest management technique that uses pest monitoring to determine if economic thresholds are exceeded before a control action is taken and chooses from a variety of pest controls, including cultural, mechanical, biological and pesticides, to manage pest population and crop damage. IPM techniques may still use pesticides to control pests but it has the potential to reduce the frequency and quantity of pesticide used.

♦ Endangered Species and Pesticides

The US Congress passed the Endangered Species Act (ESA) in 1973. The law protects animals and plants that are classified as threatened with or endangered of extinction. The ESA requires that any action taken by a federal agency may not harm a plant or animal listed under the Act. The EPA registers the use of pesticides in the US. If it is determined by the EPA that the use of a pesticide may harm a listed species, use of the pesticide may be prohibited in areas where the species occurs or otherwise restricted in some way to prevent or minimize harm.

Some pesticide products have endangered species protection statements on their label. The statements identify the species for which the restrictions apply and states what the use restrictions are. This statement generally prohibits use within the range of the listed species. In some cases, the label may direct the user to contact a regulatory agency, such as the US Fish and Wildlife Service, a state fish and game agency or a state department of agriculture before use. In the future, possession of supplemental labeling that provides additional information, range maps and use restrictions may be required before use of the pesticide product is permitted.

As of 1997, Montana has 12 species listed under the ESA.

| Threatened or Endangered Species in Montana | | | |
|--|---------------|---|--|
| <i>Species</i> | <i>Status</i> | <i>Range</i> | <i>Habitat</i> |
| MAMMALS | | | |
| Gray Wolf | Endangered | Western MT | Intermountain valleys |
| Grizzly Bear | Threatened | Northwest MT, Yellowstone Ecosystem | Mountainous forest areas, prairie foothills |
| Black-footed Ferret | Endangered | Eastern MT | Prairie dog colonies |
| BIRDS | | | |
| Bald Eagle | Threatened | Statewide | Lakes, rivers |
| Peregrine Falcon | Endangered | Statewide | Cliffs, waterfowl areas |
| Piping Plover | Threatened | Eastern MT | Shorelines & islands of ponds and rivers |
| Least Tern | Endangered | Eastern MT | Islands of rivers |
| Whooping Crane | Endangered | Statewide, rare migrant | Open fields |
| FISH | | | |
| Pallid Sturgeon | Endangered | Lower Missouri & Yellowstone Rivers | Rivers |
| White Sturgeon | Endangered | Northwest MT, Kootenai River | Rivers |
| PLANTS | | | |
| Water Howellia | Threatened | Northwest MT, Lower Swan River | Riparian |
| Ute Ladies' Tresses | Threatened | West Central MT, Madison Co. | Wetland |

CHAPTER XIII

INTEGRATED PEST MANAGEMENT

Integrated Pest Management (IPM) can be defined as:

“The intelligent selection and use of pest control actions that will ensure favorable economic, ecological and societal consequences.”

R. L. Rabb, 1972

“A sustainable approach to managing pests by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health and environmental risks.”

National Coalition for Integrated Pest Management, 1994

“A thinking farmer’s philosophy for pest management. A thoughtful, comprehensive approach to the challenge of farming, it calls on many different disciplines, seeking links and relationships among them rather than seeking to establish a separate science. It is an environmentally based pest control strategy offered as part of an overall crop production system. IPM provides a diverse array of practices that can be used together to fight crop pests in an economically and environmentally efficient manner.”

Kenneth Farrell, V.P., Agriculture and Natural Resources, University of California

A practical IPM definition for our purposes is a mixture of practices and technologies, specific to a given crop, to manage pests below a level where they are causing an economic loss to the grower. IPM is a process that continues to advance and change the way the growers manage pests to benefit the environment and their economic well being.

IPM is not new, it has been around since the beginning of farming. The present concept of IPM dates back to the beginning of this century. Farmers, agricultural researchers and farm suppliers began to work together to control agricultural pests. The earliest efforts focused mainly on cultural practices, crop rotations and plant breeding for pest resistance. IPM may be confused with organic farming. Organic farming is based on the idea that the crop is produced with no synthetic inputs for pest control or plant nutrition.

IPM can be a useful tool in managing insects, weeds, rodents, diseases and other pests if the program is well thought out and planned. IPM can provide growers with a more economically sound and environmentally friendly agroecosystem. The USDA has a goal of having IPM strategies implemented on 75% of all agricultural lands in the US by the year 2000. Sources for more information on IPM include Montana State University, local extension offices, and the Montana Department of Agriculture (MDA).

► Principles of IPM

The principles of IPM are important to understand before choosing the best tool or combination of tools to manage a pest problem. The systems approach to managing crops and pests considers their relationship with other plants, pests and their environment. Pests, their populations and population distributions within an ecosystem, are influenced by natural enemies, weather, agroecosystem, and/or other ecosystems, natural mortality, natality (reproductive rate) and food supplies.

Before devising a management strategy, an understanding of the life cycle and the type of damage the pest is causing is important. Is the pest causing damage that needs to be controlled? The highest density of the pest that can be tolerated without any significant crop loss is known as the **economic injury level (EIL)**. Some crops may be able to tolerate some damage or indirect damage without damaging the marketable part of the crop. An indirect pest, such as a leaf miner, might cause damage to the leaves of an apple tree but not direct damage to the fruit itself. The codling moth, a direct pest, causes damage directly to the fruit, causing loss of income to the grower.

The **treatment threshold (TT)**, sometimes referred to as the economic threshold, or action threshold, is the density at which control measures need to be taken to prevent the pest population from exceeding the EIL. The TT is lower than the EIL, allowing time for control measures to take effect. Not all pests have established treatment thresholds. Weeds and plant diseases often need to be controlled when they are in the early stages of development to prevent rapid buildup

Monitoring pest densities is the most fundamental, yet often the most neglected, part of IPM. Both the need for control and the effectiveness of the action taken are determined by monitoring pest and natural enemy populations. The decision to implement control is related to pest density, potential damage, and the impact of the natural enemies.

Sampling provides information on the pest life stage, population density and the ratio of pests to natural enemies. All of these are very important for making sound decisions on how to manage the pest. Management in the absence of sampling can lead to overuse or improper use of pesticides.

There are several types of sampling techniques that are used. Selection of a

Economic Injury Level and Treatment Threshold

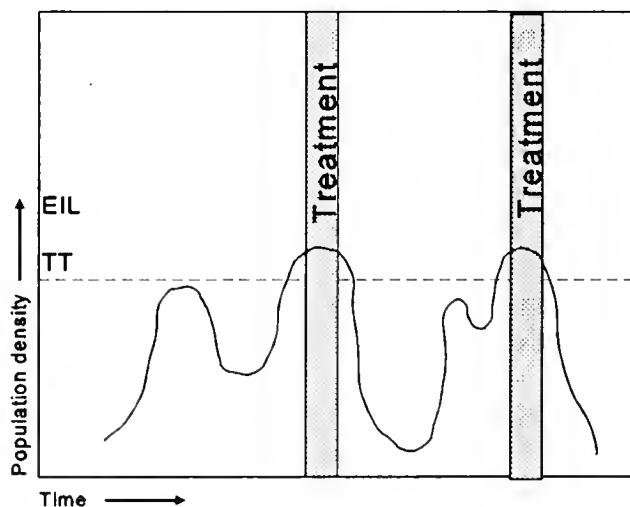


Figure 1. Economic Injury Level (EIL) and Treatment Threshold (TT)

sampling technique depends on the type of pest and monitoring objective. As an example, pheromone traps are a quick and easy way to monitor many insect pest species (cutworms, codling moth, fruit flies). **Pheromones** are a chemical, usually a glandular secretion, used in communication within a certain species of insect. By using pheromone traps, growers can learn when adult flights begin, track seasonal development and determine when populations reach the treatment thresholds. Growers can then use the information to devise a control strategy or time their pesticide application when it will be most effective.

Examples of monitoring options include:

INSECTS

- ▶ visual counts
- ▶ leaf brushing
- ▶ beating trays
- ▶ sweep net
- ▶ traps
 - pheromone
 - sticky
 - light
 - bait

WEEDS/DISEASES

- ▶ visual counts
- ▶ transects
- ▶ tissue samples

♦ Tools of IPM

☞ **Biological:** The use of natural enemies, predators, parasites and/or pathogens, which are protected, enhanced or released into the environment where the pests occur. In Montana, there are several good examples of how biological control is being used to reduce pest populations. Leafy spurge is being reduced in many areas of the state through the release of several species of flea beetles which attack the root system of this noxious weed. The flea beetles include: *Aphthona nigriscutis*, *Aphthona cyparissiae*, and *Aphthona flava*. Biological control is a long term management technique. It will take several years for a good population of natural enemies to build up and for a noticeable reduction in the pest population to occur. Time may be a draw-back, but biological control can be a permanent solution to some pest problems.

Another example of biological control in Montana is the use of larval parasites to control the cereal leaf beetle. These parasites are reared in insectaries and infected larvae are placed in grain fields where cereal leaf beetles are found. As adult parasites emerge from the hosts (infected larvae) they seek out new larvae to parasitize. Two of the larval parasites being used in Montana are *Diaparsis temporalis* and *Tetrastichus julis*.

☞ **Cultural Practices:** The use of crop rotation, cultivation, and irrigation can be used alone or in different combinations to manage pests. Cultural practices are good management practices most growers already implement, but knowing the type of pest and its life cycle, growers may be able to time these practices to optimize the impact to the pest. Early planting to avoid certain insect pests is one example of a strategy. Another might be the use of crop rotation to upset the pest's life cycle by denying a food source or place to complete it's life cycle. Cultivation can remove food sources and disrupt the life cycles of many weeds, diseases, and insects.

☒ **Pesticides:** This is the use of specific chemicals (insecticides, herbicides, insect growth regulators (IGR's), and fungicides) to reduce pest populations below an economic level. Chemicals are an important part of any IPM program. If the life cycle, feeding habits and population are known, it is possible to target just the pest at it's most vulnerable stage to reduce its population. Pesticide treatments can be targeted toward the area of the plant where the insect is feeding. This not only helps to reduce the pest population, but it also helps to maintain natural enemy populations.

☒ **Genetic:** This includes the use of **sterile release** (the release of sterile males into the pest population), resistant crop varieties and/or transgenic plants. Plant breeders have developed insect and disease resistant crops, such as wheat varieties resistant to the Hessian fly or stem rust resistant wheat varieties.

GLOSSARY

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| ABSORB | To move pesticides into a plant, animal or soil particles. |
| ADSORB | To attach to the surface, such as soil particles. |
| ACRE | 43,560 square feet. An area of land about 209 feet long by 209 feet wide. |
| ACTIVE INGREDIENT | The part of the pesticide which will kill pests or prevent damage by them. Usually it is the same as the "technical" material in the formulated product. |
| ACUTE POISONING | Severe poisoning which occurs after one exposure to a pesticide. |
| ACUTE TOXICITY | How poisonous a pesticide is to an animal after a single dose or exposure. |
| AEROSOL | Pesticide chemical stored in a container under pressure. The pesticide is driven through a fine opening by an inactive gas under pressure when the nozzle is triggered. |
| AGITATE | To keep a pesticide chemical mixed up; to keep it from settling or separating in the spray tank. |
| AGRICULTURAL CHEMICAL | A pesticide or commercial fertilizer. |
| ANTIDOTE | A treatment given by a doctor to reduce the effects of pesticide poisoning. |
| BAIT | A food or other material which will attract a pest to a pesticide or to a trap where it will be destroyed. |
| BIOLOGICAL CONTROL | Use of living organisms to control pests (Parasites, predators, diseases). |
| BROAD SPECTRUM PESTICIDES | General purpose; kills a wide range of the pest species targeted. |

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| CANCELED | A pesticide use that is no longer registered by the Environmental Protection Agency. Remaining stocks can be used by order of the Administrator, EPA. |
| CARBAMATE PESTICIDE | A family of pesticides which are chemically similar. They all attack a pest in the same way. Common ones are carbaryl (Sevin), carbofuran (Furadan) and methomyl (Lannate). |
| CARRIER | The liquid or solid that is used to dilute the active ingredient in manufacturing a pesticide formulation. Example: talc, petroleum solvents |
| CARTRIDGE | The cylinder-shaped part of the respirator which absorbs the fumes and vapors from the air before you breathe it. |
| CAUTION | A signal word used on labels of pesticides to alert users that the pesticide is slightly toxic. |
| CHEMICAL NAME | Scientific name telling the contents or formula of the active ingredients of the pesticide. |
| CHLORINATED HYDROCARBONS | A family of pesticides which are chemically similar - they all contain chlorine. They are generally very persistent as compared to carbamates or organophosphates. Examples include chlordane, lindane, methoxychlor. |
| CHRONIC POISONING | Poisoning which occurs as a result of small, repeated doses of pesticide over a long period of time. |
| CHRONIC TOXICITY | How poisonous a pesticide is to an animal (or humans) after small, repeated doses over a period of time. |
| COMMON NAME | A well-known, simple name of a pesticide accepted by the Pesticide Regulation Division of the Environmental Protection Agency. Examples: carbaryl, atrazine, benomyl. |
| DEFOLIANT | A type of pesticide which causes the leaves of a plant to drop off. |

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| DERMAL TOXICITY | How poisonous a pesticide is to an animal when absorbed through the skin. |
| DESICCANT | A type of pesticide which draws moistures (liquids) from a plant or plant part causing it to wither and die. |
| DILUENT | Generally, a liquid, commonly water, used to dilute a formulated pesticide to make a spray mixture for application. |
| DISINFECTANT | A pesticide or other chemical that kills or inactivates a disease-producing microorganisms such as bacteria. |
| DRIFT | The movement by wind and air currents of droplets or particles of a pesticide from the target area to an area not intended to be treated. |
| DUST | A finely ground, dry mixture containing a small amount of pesticide and an inert carrier, such as talc or clay. Dust particles are of many different sizes. |
| EMULSIFIABLE CONCENTRATE | A pesticide formulation with the active ingredient dissolved in an oil-based liquid with an emulsifier added, so the pesticide can be mixed with water for application. |
| EMULSIFIER | A chemical which helps one liquid form tiny droplets and thus remain mixed in another liquid. It is used to form a stable mixture between two liquids which usually would not mix. Example: oil in water. |
| ENVIRONMENTAL PROTECTION AGENCY-EPA | The federal agency responsible for pesticide laws and regulations. |
| EPA REGISTRATION NUMBER | A number assigned by EPA to a product when it is registered that must appear on all labels for that product. It will appear as "EPA Reg. No." or "EPA Registration No." Followed by the company number and product number. Sometimes a state alphabetical designation and distributors number will appear. |
| FLOWABLE | Very finely ground solid materials of pesticide which are mixed in a liquid carrier. |

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| FORMULATION | A mixture of one or more pesticides plus other materials such as carriers, diluents, etc. needed to make the pesticide safer to handle and easy to store, dilute and apply. The formulation is the form the pesticide is bought in and does not include tank mixes, adjuvants, etc. |
| FUNGICIDE | Pesticide used to control fungi. |
| GAS MASK | Type of respirator which covers the entire face; protects the eyes as well as the nose and mouth; and cleanses the air better than cartridge respirators. |
| GRANULES | A pesticide formulation of dry, ready to use, low concentrate pesticide plus an inert carrier. The particles are all about the same size and are larger than those making up a dust. |
| HAZARD | The risk of danger; the chance that danger or harm will come to the applicator, bystanders, consumers, livestock, wildlife or crops, etc. |
| HERBICIDE | Pesticide that is used to control unwanted plants. |
| INERT INGREDIENTS | Inactive part of a pesticide/formulation; any material in a pesticide mixture which would not prevent damage or destroy pests if used by itself. |
| INGREDIENT STATEMENT | The part of the label on a pesticide container which gives the name and amount of each pesticide chemical and the amount of inactive material in the mixture. |
| INHALATION TOXICITY | How poisonous a pesticide is to man or an animal when breathed in through the lungs. |
| INSECTICIDE | A pesticide that is used to control or prevent damage caused by insects. |
| INVERT EMULSIFIER | An agent or additive which allows water to remain suspended in oil rather than settling out. |
| KILOGRAM (kg) | A unit of weight in the metric system equal to 2.2 pounds. |

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| LC ₅₀ | The concentration of a pesticide in air which would kill half of the test animals exposed to it. The lower the LC ₅₀ value, the more poisonous the pesticide. It is often used as the measure of acute inhalation toxicity. |
| LD ₅₀ | The dose or amount of a pesticide which would kill half of a large number of test animals if eaten or absorbed through the skin. The lower the LD ₅₀ value, the more poisonous the pesticide. LD ₅₀ values are the commonly used measure of acute oral and acute dermal toxicity. |
| LITER | A unit of volume in the metric system (1.05 L = 1 qt). |
| MILLIGRAM (mg) | a unit of weight in the metric system, about 28,500 mg equals one ounce. |
| MITICIDE | Acaricide, a pesticide used to control mites and ticks. |
| MONTANA PESTICIDE ACT (80-8-10I-405) | A Montana state law that governs the use of pesticide in Montana and is administered by the Montana Department of Agriculture. |
| MONTANA WATER QUALITY ACT (75-5-60I et.seq.,mca) | Policy to conserve water by protecting, maintaining, and improving the quality and potability of water for public water supplies, wildlife, fish and aquatic life, agriculture, industry, recreation, and other beneficial uses; and to provide a comprehensive program for the prevention, abatement, and control of water pollution. |
| NEMATOCIDE | A pesticide used to control nematodes. |
| NEMATODE | A microscopic worm that causes damage by feeding on roots or other plant parts. |
| NONPOINT SOURCE | A diffuse source of pollutants resulting from the activities of humans over a relatively large area. |
| NON-SELECTIVE PESTICIDE | A pesticide chemical that will control a wide range of pests (broad spectrum). |
| NONTARGET | Any plant, animal or other organism that a pesticide application is not aimed at, but may accidentally be injured by the chemical. |

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| NON-VOLATILE | A pesticide chemical that does not evaporate (turn into a gas or vapor) at normal temperatures. |
| ORAL | Through the mouth. |
| ORGANOPHOSPHATE PESTICIDES | A family of pesticides which are chemically similar - they all contain phosphorous. They are generally less persistent than the chlorinated hydrocarbon family. They act by inhibiting a blood chemical called cholinesterase. Examples include malathion, diazinon, parathion. |
| ORIGINAL CONTAINER | The package (bag, can, bottle, etc.) which a pesticide is sold. The package must have a label telling what the pesticide is, and how to use it correctly and safely. |
| ORNAMENTALS | Plants used to add beauty to homes, lawns, gardens and parks. They include trees, shrubs and small colorful plants. |
| PARASITE | A plant or animal that harms another living plant or animal (called the host) by living or feeding on or in it. Sometimes parasites are helpful to humans by attacking and controlling pests which could injure crops or animals. These parasites are forms of biological control. |
| PEST | An unwanted organism (animal, plant, bacteria, fungus, virus, etc.) |
| PESTICIDE | Insecticides, herbicides, fungicides, rodenticides or any substance or mixture of substances intended for preventing, destroying, controlling, repelling, altering life processes; or mitigating any insects, rodents, nematodes, fungi, weeds and other forms of plant or animal life. |
| PHYTOTOXICITY | Injury to plant life caused by a chemical or other agent. |
| PLANT GROWTH REGULATOR | A chemical which increases, decreases or changes the normal growth or reproduction of a plant. |
| POINT OF DRIP OR RUNOFF | When a spray is applied until it starts to run or drip off the ends of the leaves and down the stems of plants or off the hair or feathers of animals. |

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| POINT SOURCE | Means a source of pollutants from a single or confined location, including but not limited to chemical mixing, loading, and storage sites and sites of agricultural chemical spills. |
| POST-EMERGENCE | After young plants push up through the soil. |
| PRE-EMERGENCE | The time period between planting seeds and the seedlings pushing up through the soil. |
| PERSONAL PROTECTIVE EQUIPMENT | Clothes and equipment that prevent or reduce exposure to pesticides during mixing, loading, or application. They would include gloves, apron, shoes, coveralls, hat, cartridge respirator and gas mask. |
| RESTRICTED-ENTRY INTERVAL (REI) | Period of time between the end of a pesticide application and when workers can safely go back into an area without protective clothing. |
| REGISTRATION | The process of approval by the Environmental Protection Agency of a pesticide for uses as stated on its label. |
| REPELLENT | A pesticide that keeps or drives insects or other pests away from the plant, animal or surface treated. |
| RESIDUE | The amount of pesticide that remains on or in a crop, animal, or surface for a period of time after it has been treated. Not the same as deposit. |
| RESPIRATOR | A face mask which filters out poisonous gases and particles from the air. |
| RODENTICIDE | A pesticide used to control rodents, such as rats, mice, ground squirrels and pocket gophers. |
| SELECTIVE PESTICIDE | A pesticide which will control only a few pest species and is not as poisonous to other plants and animals. |
| SIGNAL WORD | Word which must appear on pesticide labels to show how toxic the pesticide is. The signal words used are "Danger-Poison" or "Warning" or "Caution". |

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| SOIL INJECTION | Placing a pesticide below the soil surface with little or no soil mixing. Example: forcing a pesticide into the ground through a tube. |
| SOLUBLE POWDER | A finely ground, solid pesticide that will dissolve in water or another liquid. |
| SOLUTION | A mixture made by dissolving a solid, liquid or gas in a liquid. The mixture will not separate or settle out in normal use. Example: sugar dissolved in water. |
| SPACE SPRAY | A pesticide which is applied in the form of tiny droplets which fill the air and destroy insects and other pests, either inside or out-of-doors. |
| SPREADER-STICKER | A chemical added to a pesticide mixture to make the droplets of the spray spread out and stick better to the animal, plant or other treated surface. |
| STANDARD | The numerical value expressing the concentration of an agricultural chemical in ground water that when exceeded, presents a potential human health risk. |
| STATE WATERS | A body of water, irrigation system, or drainage system, either surface or underground. This does not apply to ponds or lagoons used solely for treating, transportation, or impounding pollutants; or irrigation waters or land application disposal waters when the waters are used up within the irrigation or land application disposal system and the waters are not returned to state waters. |
| SURFACTANT | A chemical or agent used in a pesticide formulation to make mixing easier and help the material to spread over and completely wet the surface to be sprayed. Examples: detergent, emulsifier, wetting agent. |
| SUSPENDED | A pesticide use that is no longer legal and remaining stocks cannot be used. More severe than canceled. |
| SUSPENSION | A mixture in which fine particles of a pesticide chemical are usually floating in a liquid. |

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| SYSTEMIC | A pesticide that is taken up by one part of a plant or animal and moved to another section where it acts against a pest. |
| TOLERANCE | The amount of a pesticide residue that can legally remain on any food (plant or animal) that is to be eaten by livestock or humans. The tolerance is set by the Environmental Protection Agency. |
| TOXIC | Poisonous, deadly, injurious to plants, animals or humans. |
| TOXICANT | A poison. The chemical in a pesticide formulation that can injure or kill the pest. |
| TOXICITY | How poisonous a pesticide is to a living organism. |
| ULTRA-LOW VOLUME (ULV) | The application of a highly concentrated pesticide in extremely small amounts over a large area-usually only a few ounces per acre. |
| WETTABLE POWDER | A pesticide formulation in the form of powder that is mixed with water to be applied. It does not dissolve in the water but forms a suspension. |
| WETTING AGENT | An additive which helps the pesticide spread out and coat a surface more evenly. |

ABBREVIATIONS & MEANINGS

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| BMP | Best Management Practices |
| CFR | Code of Federal Regulations |
| CIS | Consumer Information Sheets |
| DEQ | Department of Environmental Quality |
| EIL | Economic Injury Level |
| ESA | Endangered Species Act |
| FIFRA | Federal Insecticide, Fungicide and Rodenticide Act |
| GMP | Ground Water Management Plan |
| IPM | Integrated Pest Management |
| LPC | Livestock Protection Collar |
| MACGWPA | MT Agricultural Chemical Ground Water Protection Act |
| MDA | Montana Department of Agriculture |
| MESA | Mining Enforcement and Safety Administration |
| MPA | Montana Pesticides Act |
| MSDS | Material Safety Data Sheets |
| MWQA | Montana Water Quality Act |
| NIOSH | National Institute for Occupation Safety Health |
| OPM | Ounces Per Minute |
| OSHA | The Occupational Safety and Health Administration |
| PCO | Pest Control Operator |
| PPE | Personal Protective Equipment |
| REI | Restricted Entry Intervals |
| TT | Treatment Threshold |
| ULV | Ultra Low Volume |
| VMD | Volume Mean Diameter |
| VPI | Vapor Pressure Indexes |
| WPS | Worker Protection Standard |



